ORBITAL EXPRESS
ADVANCED TECHNOLOGY DEMONSTRATION
(Orbital Express ATD)

PHASE I:
Concept Definition and Preliminary Design

SELECTION PROCESS DOCUMENT
(“SOLICITATION”)
RA00-37

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Defense Advanced Research Projects Agency
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1.0 Introduction

The Defense Advanced Research Projects Agency (DARPA) is pleased to offer you the opportunity to respond to the Orbital Express Space Operations Architecture ("Orbital Express") Advanced Technology Demonstration (ATD) solicitation.[1] As you explore this solicitation we believe you will appreciate this unique opportunity to work in partnership with the U.S. Government to demonstrate the operational utility, cost effectiveness, affordability, and technical feasibility of a new architecture for autonomous, preplanned, on-orbit electronics upgrade, refueling and reconfiguration of satellites that will be capable of supporting a broad range of future U.S. national security, civil and commercial space programs.

1.1 Vision

The Orbital Express program is envisioned to set the stage for the establishment of a routine, cost-effective, autonomous capability for re-supply and reconfiguration of on-orbit spacecraft in the post-2010 timeframe. We believe an Orbital Express-derived satellite servicing architecture will usher in a revolution in space operations, enabling new and enhanced satellite capabilities supporting not only national security missions, but civil and commercial space activities as well.

DARPA believes routine, autonomous satellite refueling will extend the useful lifetime of satellites, will provide spacecraft with unprecedented freedom of maneuver, allowing satellite coverage to be adjusted, or optimized, at will, or alternatively, enable spacecraft to employ unpredictable maneuvers to counter possible threats or adversary activity scheduling. We also anticipate that routine, autonomous, preplanned upgrades or reconfiguration of spacecraft components will result in substantial reductions in space system acquisition and launch costs by significantly extending satellite on-orbit mission lifetimes and permitting reductions in spacecraft launch volume and mass.

DARPA's vision of post-2010 space operations foresees satellites designed and equipped with Orbital Express-derived standardized mechanical and electrical interfaces enabling their automated receipt of fluid consumables (fuel and cryogens) and upgraded electronic components via an unmanned servicing spacecraft (a so-called "Autonomous Space Transfer and Robotic Orbiter" vehicle, or ASTRO).

Notionally, multiple ASTRO servicing spacecraft will remain permanently on-orbit, with each assigned to service satellites within a specified range of orbital inclinations and altitudes. Bulk

[1] Advanced Technology Demonstrations (ATDs) are used by the Department of Defense to develop, demonstrate, and evaluate emerging technologies, and are typically integrated demonstrations conducted to assess the feasibility and maturity of an emerging technology. They provide a relatively low-cost approach for assessing the technical risks and uncertainties associated with critical technologies prior to their possible incorporation into a system entering the formal acquisition process. If successful, an ATD can lead to a distinct acquisition program, or its demonstrated technologies can be integrated into another, larger acquisition program.

fluids or electronic component upgrade units will be launched into orbit using relatively inexpensive space launch vehicles. Fluid consumables and hardware components will be launched into orbit at a sufficiently low cost and in sufficient volume that they effectively become space "commodities." ASTRO servicing spacecraft will autonomously rendezvous and dock with these commodity payloads, and will on-load replenishment fluids or orbital replacement unit (ORU) components/systems destined for specified satellites to be serviced.

The ASTRO spacecraft will then autonomously transit between an on-orbit commodity payload and the satellite to be serviced (effecting any required orbital plane or altitude changes), accomplish autonomous rendezvous and docking, perform preplanned robotic fluid transfer or ORU installation, autonomously undock and separate from the serviced satellite, and then transit to another commodity payload, and repeat the servicing cycle for another satellite.

It is also envisioned that the ASTRO spacecraft will be capable of autonomously rendezvousing with, docking with / on-loading, and off-loading / undocking from microsatellites, and carrying and independently operating microsatellites as functioning ASTRO payloads.

To capitalize on the availability of servicing spacecraft and affordable replenishment and upgrade commodities, satellites of the future (or "NEXTSats") will be designed to enable routine, autonomous on-orbit servicing. That will require that a non-proprietary, "open" industry standard for satellite-to-satellite servicing interfaces be adopted to ensure on-orbit servicing compatibility among ASTRO's and NEXTSat's designed and produced by different manufacturers. It will also necessitate that NEXTSats be designed such that fluid transfer interfaces and ORU installation ports be unobstructed and readily accessible by an autonomous servicing spacecraft.

DARPA believes the success of the Orbital Express ATD program will facilitate the realization of our vision of routine, autonomous on-orbit satellite servicing, and in so doing will prompt a revolution in both system acquisition and in the flexibility with which national security, civil and commercial space systems are employed. By enabling the adoption of an aircraft-like preplanned product improvement design philosophy, the cost of acquiring and operating satellite systems will be drastically reduced. And by enabling routine consumable replenishment analogous to aircraft in-flight refueling, for the first time, space systems will be conferred with unprecedented mobility, permitting smaller numbers of satellites to accomplish critical national security missions, or infusing sufficient resiliency and adaptability in commercial constellations that the loss of service that would otherwise result from a catastrophic on-orbit satellite failure can be rapidly and affordably mitigated or fully restored.

1.2 Program Philosophy

DARPA believes the Orbital Express ATD will redefine how we design and operate spacecraft in the future. The details of that redefinition will be left to you, however, as members of a select Government / industry team charged with making the Orbital Express vision a reality. **The operational concept advanced in Section 1.1 is notional.** It is intended only to illustrate DARPA's vision of routine, autonomous re-supply and reconfiguration of Earth-orbiting spacecraft in the post-2010 timeframe. **This solicitation asks you to advance your own ideas:**

to be imaginative and innovative; and to "push the envelope" both technically and operationally. DARPA will not provide traditional specifications or a statement of work. Instead, we will describe our objectives in this solicitation and provide guidance on preparing your response. We will set the bounds of the problem, and you, the offeror, will perform analyses, trade studies and risk reduction activities that will translate your Operational System Concept (OSC) into a conceptual design for a post-2010 Orbital Express Operational System (OEOS), and ultimately, into a preliminary design for an Orbital Express Demonstration System (OEDS) that will provide a best value solution to our ATD objectives.

As a DoD prototype demonstration, the Orbital Express ATD's immediate emphasis is necessarily on demonstrating the applicability of satellite servicing to one or more U.S. national security space missions. However, if on-orbit servicing is to revolutionize the manner in which we design and operate spacecraft in the future, it must be shown to be relevant to a significant fraction of Earth-orbiting satellites. Therefore**, in addition to demonstrating the applicability of on-orbit servicing to U.S. national security spacecraft, it is DARPA's intent that the Orbital Express program also demonstrate the applicability of satellite servicing to the largest possible number of civil and commercial spacecraft as well**.

The products of the Orbital Express ATD must enable decision makers to determine whether on-orbit satellite servicing is sufficiently useful, cost effective, affordable, and technically feasible to continue development of the Orbital Express architecture after completion of the ATD's on-orbit demonstration. Therefore, substantiation of the cost effectiveness and affordability of satellite servicing, the development and demonstration of a standardized satellite-to-satellite servicing interface, development and demonstration of autonomous satellite servicing operations, and exploitation of state-of-the-art robotics are key to the success of the Orbital Express ATD.

1.2.1 Cost Effectiveness, Life-Cycle Cost and Affordability

Although there is no unit price requirement for the Orbital Express Demonstration System, estimated Orbital Express Operational System cost effectiveness and life-cycle cost, and by extension, servicing architecture affordability, is critical to the viability of routine satellite servicing. Therefore, the offeror shall treat system cost effectiveness and life-cycle cost as technical requirements, and make intelligent choices that ensure the ultimate Operational System and Demonstration System design requirements reflect a balance between capability and affordability, recognizing that the affordability of both the Demonstration System and the envisioned Operational System will be critical to the success of the Orbital Express ATD program.

For the Operational System, this ratio of effectiveness-to-affordability should be optimized using scenarios and mission benchmarks representative of operations in the post-2010 timeframe.

For the Demonstration System, emphasis should be placed on providing maximum capability to the Government for a pre-determined level of Phase II funding. Accordingly, we expect the offeror to conduct continuous cost/performance trades throughout the course of the program, both Phase I and Phase II, to arrive at the best solution and perform the most meaningful demonstration of portions of the Operational System with the Demonstration System. For the

Demonstration System, the offeror shall consider Cost as an Independent Variable (CAIV), and shall "design-to-cost," for each Phase.

If, as a result of the analysis and trade studies conducted during Phase I, either the Demonstration System or the Operational System were shown to be unaffordable, the Orbital Express program would not advance to Phase II.

1.2.2 Non-Proprietary Satellite Interface Specification

Central to the realization of DARPA's vision for future space operations is the availability of the interface control documents for satellite-to-satellite servicing interfaces for use on satellites designed and produced by different manufacturers. To facilitate the emergence and acceptance of standard servicing interface documents the contractor shall develop an Interface Control Document for each of the specified Non-Proprietary Interfaces. (Interfaces defined as those features that relate to the areas where the ASTRO touches the NEXTSat, Commodity Payload, ORU or MicroSatellite. These interfaces will be defined on an Interface Control Document, (ICD).

The ICD will contain the necessary interface dimensions and performance requirements necessary to meet the objective of the system. DARPA is not interested in a classified satellite-to-satellite interface design, a proprietary design, or an interface design lacking legacy beyond the Orbital Express on-orbit demonstration. Therefore, a specific DARPA objective in the Orbital Express ATD program will be to take delivery, during Phase I of the Preliminary Interface Control Document (ICD) and delivery of the Final ICD, including drawings and documents or the satellite-to-satellite mechanical and electrical interfaces, source code and full documentation for all enabling software, and specification of associated protocols (e.g., communications, satellite states and modes, etc.), developed for the Orbital Express program. In short, the satellite-to-satellite ICD's, enabling software source code and documentation, and associated protocol specifications for the Orbital Express ATD program must be delivered to the Government free of restriction on their use or further distribution. ICD's for the interfaces, software and protocols that must be non-proprietary are those on which the autonomous functionality of the ASTRO servicing spacecraft is dependent. (See Figure 1.1.)

Generically, there are mechanical and electrical satellite-to-satellite interfaces, software and protocols enabling autonomous docking (#1) and fluid consumable transfer (#2) between the ASTRO and commodity payloads, and between the ASTRO and NEXTSat serviceable satellites; the mechanical and electrical satellite-to-satellite interfaces, software and protocols enabling the ASTRO to autonomously on-load ORUs from commodity payloads, transport ORUs to a serviceable satellite, and to transfer ORUs to a NEXTSat (#3); and, those mechanical and electrical satellite-to-satellite interfaces, software and protocols enabling the ASTRO to autonomously dock with, on-load and off-load microsatellites, and carry and independently operate microsatellites as functioning ASTRO payloads (#4). Those interfaces between ORUs and NEXTSat serviceable satellites on which the functionality of ORUs are dependent may be retained as proprietary. Precise definition of the non-proprietary mechanical and electrical interface enabling software, and associated protocols will be accomplished in a series of servicing interface Technical Interchange Meetings (TIMs) after Milestone 1 (see Section 2.4.1).

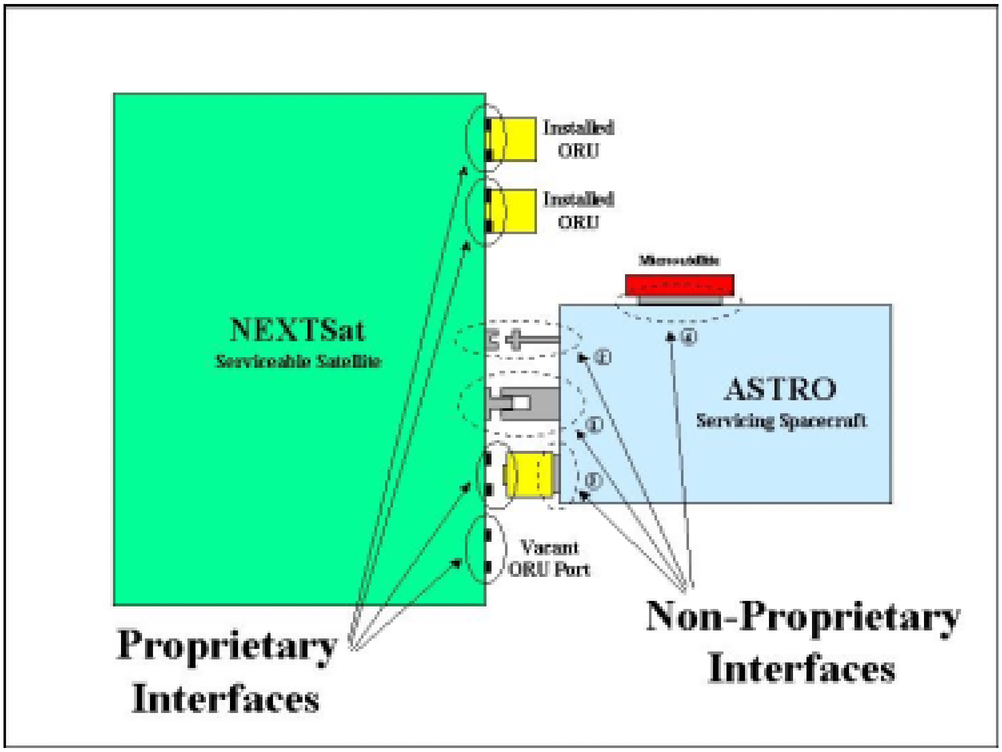

Figure 1.1 Non-Proprietary and Proprietary Interfaces

1.2.3 Design and Manufacture of Demonstration Systems

To ensure maximum credibility in demonstrating the Orbital Express satellite servicing interface, and to substantiate that the Demonstration System interface can serve as a de facto initial industry standard, the prototype ASTRO servicing spacecraft and the spacecraft functionally emulating the prototype servicing architectures of both a NEXTSat serviceable satellite and a space commodity payload (see Section 1.2.6) must be manufactured by different team members.

1.2.4 Autonomous Satellite Servicing

DARPA's goal for the Orbital Express program is fully autonomous satellite servicing. We are not interested in an ATD program in which astronauts direct or participate in satellite servicing operations, or concepts that rely on remote control by ground facilities. Instead, the Orbital Express program intends to eliminate human participation in satellite servicing and rely on advances in automation and robotics to accomplish fluid and hardware transfers between the servicing and serviced spacecraft. Reducing human involvement in satellite servicing will increase the potential frequency and speed of servicing missions, and will reduce the cost of performing such missions. Hence, eliminating human involvement is a key to making on-orbit servicing routine and cost-effective. Accordingly, the design and development of the ASTRO servicing spacecraft's prototype autonomous Guidance, Navigation and Control (Auto-GN&C) system is a specific objective of the Orbital Express ATD program.

1.2.5 Technology Risk Reduction

DARPA reserves the right to support separate technology risk reduction efforts in parallel to the Orbital Express system definition and design activity. Risk reduction efforts may be solicited separately in future Research Announcements, Broad Agency Announcements, or possibly through Small Business Innovation Research (SBIR) efforts. The Government will facilitate risk reduction contractor support of the Orbital Express definition and design effort by conducting Integrated Open Reviews (IORs) at which risk reduction analyses and study results, technology research and development results, hardware and software specifications and designs, and test results will be reported to the Orbital Express definition and design teams. It is the Government's intention that industry teams who are awarded Orbital Express definition and design efforts as a result of this solicitation should continuously assess whether and how parallel risk reduction performers should be added to their teams.

1.2.6 Use of Surrogate Commodity Payload and Serviceable Spacecraft

The Orbital Express ATD demonstration is not expected to involve on-orbit servicing of an operational satellite. Instead, DARPA envisions the on-orbit demonstration using a uniquely designed spacecraft (a NEXTSat and commodity payload surrogate) that functionally emulates the prototype servicing architectures of both a serviceable satellite and a space commodity payload. The surrogate spacecraft will support the demonstration of automated fluid and hardware transfers to and from a servicing spacecraft (see Section 2.3).

1.2.7 Use of Section 845 Authority

A critical element of the Orbital Express ATD program is the use of "industry teams" – preferably formed on a nonexclusive basis – that are composed of "team leaders" and "team members," rather than traditional prime contractors and subcontractors. Industry teams de-emphasize organizational hierarchical relationships, produce optimal task-organized mixes of technical talent, and minimize program indirect costs. To facilitate the role of teams, the Orbital Express ATD program will be executed as an "Other Transaction for Prototypes," using DARPA's authority under Section 845, National Defense Authorization Act for Fiscal Year 1994, as amended. This flexible authority permits wide latitude in tailoring business, organizational and technical relationships to achieve program goals, and relieves team members of expensive and burdensome Government oversight, such as providing certified cost or pricing data or adhering to Government-established cost accounting standards. Section 845 authority also offers teams the flexibility to adopt alternative business and technical practices as desired, and allows much freer exchange of information between the Government and industry team members. Because of the collective advantages of Section 845 agreements, it is hoped their use will attract and facilitate the participation of commercial firms that traditionally do not do business with the Government, and thereby afford DARPA access to a broader range of technologies and technical expertise than it would otherwise enjoy. In addition, as a byproduct, Section 845 authority also has important implications for the structure of this solicitation, the breadth of issues prospective offering teams must consider, and the actual proposal structure itself.

1.2.8 Multi-Phase Program Structure

DARPA has structured the Orbital Express Advanced Technology Demonstration as a two-phase program using its authority under Section 845, National Defense Authorization Act for Fiscal Year 1994, as amended. For Phase I, DARPA expects to make two or more Section 845 awards to industry teams. During Phase I, requirements for on-orbit satellite servicing will be identified, defined and analyzed; utility, cost effectiveness and life-cycle cost analyses will be performed; an Operational System Concept will be refined; a baseline satellite servicing mission and servicing CONOPS will be identified and defined; risk reduction R&D activities will be initiated; a conceptual design of an Orbital Express Operational System (OEOS), hereafter referred to simply as the "Operational System," will be developed; and the preliminary design of the Orbital Express Demonstration System (OEDS), hereafter referred to as the "Demonstration System," will be completed.

If Phase II is approved, a new competition will be held prior to the completion of Phase I – limited to Phase I teams – and a team will be selected to execute Phase II of the ATD program.

During Phase II, detailed design of the Demonstration System will be completed; the prototype system will be developed, fabricated, integrated and space-qualified; Demonstration System spacecraft will be launched; and, an on-orbit satellite servicing demonstration will be conducted using the prototype Demonstration System to perform multiple satellite servicing cycles involving automated satellite-to-satellite transfers of both fluids and hardware.

1.2.9 Phase I Award Qualifications

Only teams judged to be capable of successfully completing both Phase I and Phase II of the Orbital Express ATD program will be judged to be qualified for a Phase I award.

Team leads must also be capable of obtaining access to U.S. Government Sensitive Compartmented Information (SCI) to ensure that critical team analyses and trade studies conducted early in Phase I fully consider U.S. national security space missions as well as civil and commercial space activities.

1.2.10 Cost Sharing

In view of the envisioned future civil and commercial space applications of on-orbit satellite servicing, industry cost sharing is acceptable.

1.3 Solicitation Package Overview

In response to this solicitation you are asked to submit your own Operational System Concept (OSC), Task Description Document (TDD), Integrated Master Plan (IMP), Integrated Master Schedule (IMS), and Cost Responses. Your solicitation response will be integrated into a Section 845 Agreement that will govern the relationship between you and the Government during this program. **OFFERORS ARE EXPRESSLY CHARGED WITH KNOWLEDGE OF THE CONTENTS OF THE ENTIRE SOLICITATION.**
Following is an overview of each section of this solicitation and its intended use:

Program Description: This section of the solicitation describes the motivation, goal, and objectives of the entire program and provides details on the scope of your work effort. This section also provides the offeror with an overview of the contracting mechanism and financial resources available to the program.

Proposal Guidance: This section of the solicitation provides the offeror guidance for the development of a unique Task Description Document (TDD), Integrated Master Plan (IMP) and Integrated Master Schedule (IMS). The guidance contained in this section applies to Phase I of the Orbital Express ATD program. It is anticipated that these instructions will evolve as the Orbital Express ATD program matures and that they will be updated for the Phase II solicitation. Although these instructions are not intended to be all-inclusive, they should be considered by each offeror as they develop their proposed Agreement.

Evaluation Criteria: This section is intended to give the offeror a clear picture of how the Government will evaluate proposals.

Proposal Instructions: This section provides administrative and format guidance for preparing and presenting proposals in response to this solicitation. This includes instructions for preparing the Executive Summary, OSC, and Cost Responses.

Model Agreement: This section provides a model agreement for assistance in preparing your proposal.

General Information: This section provides general information and statutes required to make this solicitation complete.

Appendix A: System Capability Document. This appendix describes the design and performance trade space boundaries for the offeror's OSC and Phase I Operational System development. Additional guidance on desired Demonstration System capabilities will be released at the Phase 1 System Requirements Review (SRR) following Milestone 1.

Appendix B: Section 845 "Other Transaction for Prototypes" Questionnaire. This appendix presents two questions that DARPA requests you answer in conjunction with your proposal submission. Your response will, in part, form the foundation of a DARPA report to DoD and Congress. You are asked to detail how an Orbital Express Section 845 "Other Transaction for Prototypes" agreement (if awarded to your team) will contribute to a broadening of the technology and industrial base available for meeting Department of Defense needs, and how an Orbital Express Section 845 “Other Transaction for Prototypes” agreement (if awarded to your team) will foster new relationships and practices that support the national security of the United States.

Appendix C: Glossary. This appendix provides definitions for acronyms used in this solicitation.

2.0 Program Description

2.1 Motivation

Today's Department of Defense (DoD) space architecture labors under significant limitations that would be substantially mitigated – perhaps eliminated – by the adoption of on-orbit satellite servicing.

Operationally, concerns over prolonging the availability of a small number of difficult-to-replace, very-high-value assets necessitates accepting diminished mission capability when spacecraft are impaired by noncatastrophic system degradation. Minimal satellite maneuverability – imposed by a limited quantity of nonreplenishable onboard fuel - also makes satellite orbital characteristics predictable, allowing adversaries to schedule their activities around satellite access opportunities. The absence of maneuverability also severely limits the ability of DoD constellations to quickly respond to operational contingencies by modifying their orbits to optimize their coverage. In addition, finite quantities of onboard fuel and cryogen consumables impose absolute limits on the mission lifetime of satellites.

Current DoD Concepts of Operations (CONOPS) necessitate system design practices that result in significantly increased space system cost. Concerns over assured system availability necessitate the adoption of a highly risk-intolerant posture, imposing the costly requirement to equip satellites with multiple redundant mission-critical systems and to accommodate excessively large consumable fractions. This practice produces inflated system acquisition costs, and magnifies required launch costs by increasing satellite launch mass and volume.

Consequently, DARPA believes routine, automated satellite refueling will extend the useful lifetime of satellites, will provide spacecraft with unprecedented freedom of maneuver, allowing satellite coverage to be adjusted, or optimized at will, or alternatively, enable spacecraft to employ unpredictable maneuvers to counter possible threats or adversary activity scheduling. We also anticipate that routine, autonomous, preplanned upgrades or reconfiguration of spacecraft components will result in substantial reductions in space system acquisition and launch costs by significantly extending satellite on-orbit mission lifetimes and permitting reductions in spacecraft launch volume and mass.

2.2 Goal

The goal of the Orbital Express ATD program is to demonstrate the operational utility, cost effectiveness, affordability, and technical feasibility of a new architecture for autonomous, preplanned electronics upgrade, refueling and reconfiguration of satellites on-orbit that will be capable of supporting a broad range of future U.S. national security, civil and commercial space programs.

2.3 Objectives

The primary objective of the Orbital Express ATD is to define, design, develop, integrate and demonstrate a new space architecture enabling routine autonomous satellite servicing in the post-2010 timeframe. The specific objectives of the Orbital Express ATD include:

- Substantiation of the operational utility, cost effectiveness and affordability of routine autonomous satellite on-orbit servicing.
- Identification of the baseline U.S. national security space mission (or mission set) – and the associated serviceable satellite design(s) -- offering the greatest operational utility and cost effectiveness leverage for on-orbit servicing.
- Definition of a baseline satellite servicing CONOPS.
- Definition, design, development and integration of non-proprietary satellite-to-satellite mechanical and electrical interfaces, enabling software and associated protocols for fluid and hardware transfers that will serve as the baseline industry standard for satellite servicing.
- Definition, design, development, fabrication, and test and integration of the ASTRO servicing spacecraft's prototype Auto-GN&C system, a prototype ASTRO servicing spacecraft, and a prototype servicing architecture applicable to a NEXTSat serviceable satellite (of a type relevant to the baseline satellite servicing mission, or mission set) and a commodity payload (fitted with fluid consumables and/or hardware ORUs).
- On-orbit demonstration of routine autonomous satellite servicing by performing a series of automated satellite-to-satellite fluid and hardware transfers using prototype servicing interfaces, a prototype servicing spacecraft and a spacecraft functionally emulating the prototype servicing architectures of both a NEXTSat serviceable satellite and a commodity payload. Each servicing cycle in the series of autonomous on-orbit satellite servicing demonstrations will involve:
    1. The servicing spacecraft autonomously accomplishing necessary orbital altitude and plane changes to achieve orbit matching with a surrogate spacecraft that functionally emulates the prototype servicing architecture of an on-orbit commodity payload.
    2. The servicing spacecraft autonomously approaches and docks with the surrogate spacecraft emulating a commodity payload.
    3. The servicing spacecraft on-loads fluid consumables (e.g., fuel or cryogens) and/or ORUs from the surrogate commodity payload.
    4. The servicing spacecraft autonomously undocks and separates from the surrogate commodity payload.
    5. The servicing spacecraft autonomously accomplishes necessary orbital altitude and plane changes to again achieve orbit matching with the surrogate spacecraft that also functionally emulates the prototype servicing architecture of a serviceable satellite.
    6. The servicing spacecraft autonomously approaches and docks with the surrogate spacecraft now emulating a serviceable satellite.
    7. The servicing spacecraft transfers fluid consumables (e.g., fuel or cryogens) and/or ORUs to the emulated serviceable spacecraft.
    8. The servicing spacecraft autonomously undocks and separates from the surrogate spacecraft emulating a serviceable satellite.

Your ability to identify and define future operational system effectiveness and affordability requirements, and then use those requirements as a filter in your selection of the critical technologies to be matured and validated during the ATD, is vital to the success of this program.

2.4 Program Plan

The Orbital Express ATD program is divided into two distinct phases, as shown in Figure 2.1. During Phase I, DARPA will award two or more, 14-month, Section 845 agreements. Initially, Phase I teams will identify, define and analyze the requirements for on-orbit satellite servicing; perform utility, cost effectiveness and life-cycle cost analysis; refine an Operational System Concept (OSC); nominate a baseline satellite servicing mission; and, define a servicing CONOPS. Teams will submit their preliminary analyses and trade study results within three months, at Milestone 1. Following Milestone 1, DARPA will conduct a Systems Requirements Review (SRR).

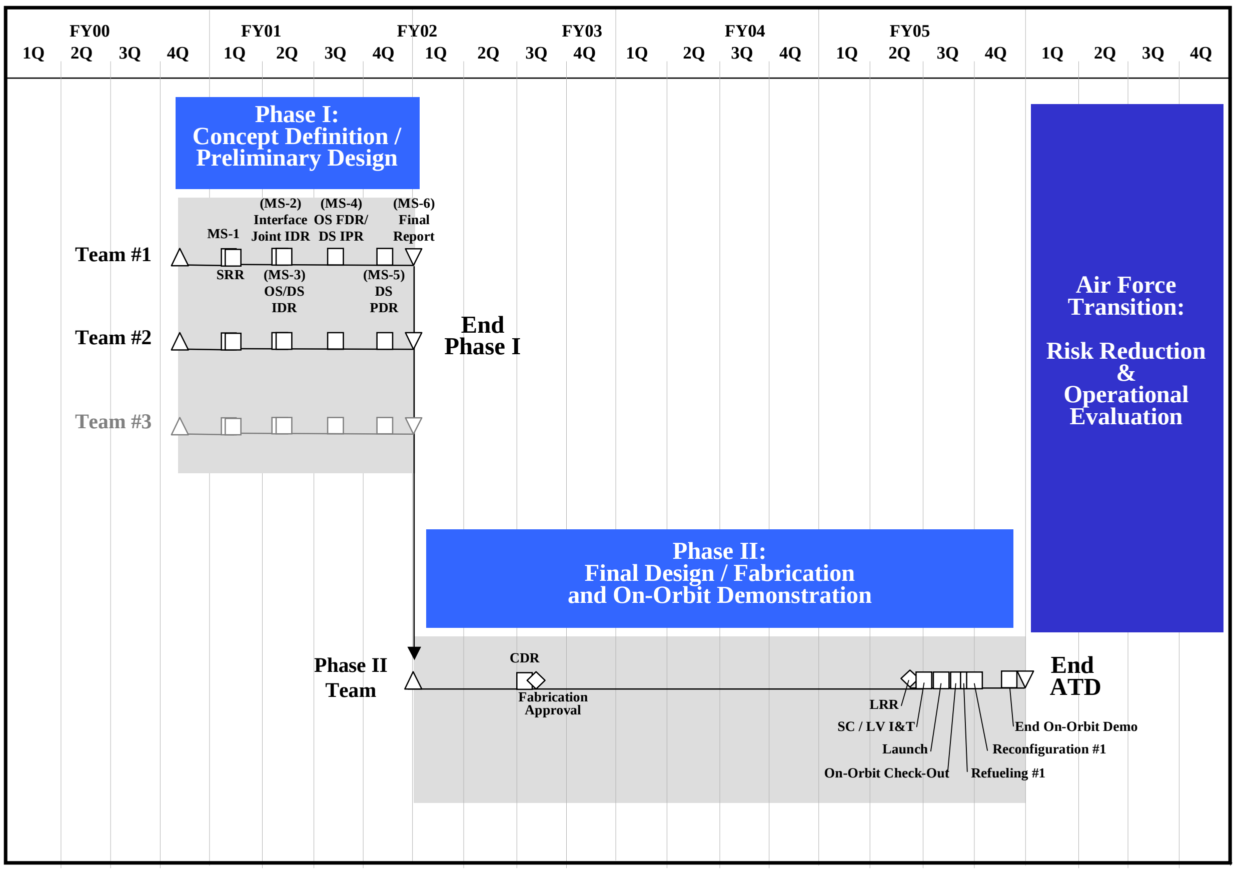

Figure 2.1: Notional Orbital Express Program Schedule

Following the SRR, Phase I teams will initiate risk reduction R&D activities; develop a conceptual design of an Operational System; and, complete preliminary design of a Demonstration System (i.e., prototype satellite-to-satellite servicing interface, the ASTRO servicing spacecraft's prototype Auto-GN&C system, the prototype ASTRO servicing spacecraft, a spacecraft functionally emulating the prototype servicing architectures of both a NEXTSat serviceable satellite and a commodity payload, and ground facility support of on-orbit testing). The Demonstration System is intended to validate a team's Operational System Conceptual design and concept of operations in an on-orbit demonstration during Phase II.

At the conclusion of Phase I, DARPA, in consultation with the Air Force and NRO, will determine whether to enter Phase II or conclude the program. The decision will be based on a thorough assessment of the results of Phase I as well as the extent to which team-proposed Phase II programs will provide significant value added to the Government. Should DARPA decide to proceed with Phase II, two alternative acquisition strategies (described below) are under consideration. The acquisition strategy to be adopted will be decided during Phase I.

- Phase II, Strategy One: The Government would select one Phase I team to complete the Demonstration System design; continue risk reduction R&D activities; develop, fabricate, integrate and test, and space-qualify the Demonstration System; support spacecraft / launch vehicle integration; arrange ground facility support for on-orbit test operations; and, conduct an on-orbit satellite servicing demonstration using the Demonstration System to perform multiple satellite servicing cycles involving automated satellite-to-satellite transfers of both fluids and hardware.

- Phase II, Strategy Two: In an effort to obtain the best solution for the Orbital Express Demonstration System, the Government would select a specific Phase I team to complete and provide a specific Demonstration System subsystem (i.e., the ASTRO servicing spacecraft's prototype Auto-GN&C system, the prototype ASTRO servicing spacecraft, and a spacecraft functionally emulating the prototype servicing architectures of both a NEXTSat serviceable satellite and a commodity payload), as well as to conduct an on-orbit satellite servicing demonstration using the Demonstration System to perform multiple satellite servicing cycles involving automated satellite-to-satellite transfers of both fluids and hardware. Under Strategy Two, the team selected to provide the prototype ASTRO servicing spacecraft would form and lead the new composite team, would serve as the Demonstration System System Engineer and Integrator (SE&I), and would be responsible for coordinating ground facility support of on-orbit test operations.

Demonstration System space launch vehicle manifesting will not be a team responsibility under this agreement. "Design-to" launch vehicle options to be considered in developing designs for the Operational and Demonstration systems will be identified by the Government at the Phase I SRR.

Only Phase I teams will be eligible to participate in Phase II. Team leads awarded agreements for Phase I will remain team leads for Phase II, unless another team member is so specified in the team's Phase I proposal. Team composition for Phase II may be fluid, to allow the inclusion of parallel risk reduction performers (see section 1.2.5), if appropriate. The Phase II Solicitation will be provided to the Phase I teams approximately ten (10) months after the start of Phase I. Two alternative Phase II acquisition strategies under consideration (the strategy to be adopted will be decided at a later date). Under one alternative, the Government would select one Phase I team to complete Phase II. Under the second alternative, DARPA would attempt to obtain the best solution for the Orbital Express Demonstration System, and would select a specific Phase I team to complete final design, development, integration and test, and space qualification of a specific Demonstration System subsystem: 1) the ASTRO servicing spacecraft's prototype Auto-GN&C system; 2) the prototype ASTRO servicing spacecraft (to include serving as the Phase II team lead, the Demonstration System SE&I, and coordinator of ground facility support of on-orbit test operations); and , 3) the spacecraft functionally emulating the prototype servicing architectures of both a NEXTSat serviceable satellite and a commodity payload).

Phase II is scheduled to last approximately 38 months.

Additional information on Orbital Express mission description and system capabilities is provided in Appendix A.

2.4.1 Phase I: Concept Definition and Preliminary Design

Teams will perform requirements analyses, cost analyses, concept definition, design trade studies, and risk reduction activities to progressively transition their Operational System Concept into an Orbital Express Operational System conceptual design, and then an Orbital Express Demonstration System preliminary design.

Each team will identify and define satellite servicing requirements, considering historical satellite on-orbit failure mode data relevant to U.S. national security space missions, as well as the nature and operational impact of nonuniform rate of obsolescence of satellite subsystems / components. Teams will assess the operational utility, cost effectiveness and life-cycle cost of autonomous satellite servicing and, in so doing, will conduct a comprehensive set of "repair vs. replace" and "remove-and-insert" versus "plug-and-stay" trade studies. Early in Phase I, based on the results of their analyses and trade studies, teams will nominate a U.S. national security space mission, or mission set, (including identification of specific servicing objectives) to serve as the Orbital Express baseline satellite servicing mission. Baseline mission nominations will be supported by analysis of satellite failure modes relevant to U.S. national security space missions, analysis of satellite subsystem / component obsolescence, preliminary operational utility and cost effectiveness assessments, and a risk analysis of satellite servicing enabling technologies. Each team will also refine their Operational System Concept and define a satellite servicing CONOPS.

The Government will consider team nominations, and will designate (at the SRR) a single Demonstration System baseline satellite servicing mission (or mission set) to be used by all teams in developing their Operational System conceptual design and their Demonstration System preliminary design. Each team will then proceed with development of a conceptual design for an Orbital Express Operational System.

Since it is DARPA's intent that a non-proprietary industry standard satellite servicing interface will result from the Orbital Express ATD, all Phase I system designs must be normalized to the same satellite servicing interface. To encourage and facilitate team consensus on a single interface specification, following designation of the baseline satellite-servicing mission, the DARPA Program Manager will chair a series of servicing interface Technical Interchange Meetings (TIMs). The servicing interface TIMs will be non-proprietary forum, and will be jointly attended by all teams. Each team's concept and design-to-date for the prototype satellite-to-satellite mechanical and electrical interfaces, enabling software and associated protocols will be reviewed in detail and critiqued at each TIM. This consensus approach will produce iterative convergence by the Phase I teams on a single preliminary design for the Orbital Express satellite servicing interface.

Risk assessment / risk mitigation plans and supporting technology development plans will be developed, necessary enabling technology risk reduction R&D activities will be initiated, and concepts for the on-orbit demonstration and preliminary test plans will be developed (to include identification of the supporting ground facility and necessary prior arrangements to obtain ground facility support).

Finally, each team will complete a preliminary design for the Orbital Express Demonstration System (i.e., the prototype satellite-to-satellite interface, the ASTRO servicing spacecraft's prototype Auto-GN&C system, a prototype ASTRO servicing spacecraft, a spacecraft functionally emulating the prototype servicing architectures of both a NEXTSat serviceable satellite and a commodity payload, and ground facility support). The Demonstration System will be designed to validate the critical technologies for, and provide a direct legacy to, a team's Operational System conceptual design. The Demonstration System design should be capable of fully addressing as many of the specific Orbital Express ATD technical objectives as possible (as defined in section 2.3), while providing best value to the Government. Teams have the freedom to consider demonstration spacecraft scaling if it will enable their Demonstration System to achieve a significantly greater set of program objectives for a given cost.

Each team will produce documentation such as an Operational System utility / requirements analysis, cost effectiveness analysis, life-cycle cost analysis, baseline U.S. national security satellite servicing mission analysis, an Operational System Concept, and a satellite servicing CONOPS. Each team will also develop an Operational System conceptual design, a Demonstration System preliminary design (for the prototype satellite-to-satellite servicing interface, a prototype ASTRO servicing spacecraft, the ASTRO servicing spacecraft's prototype Auto-GN&C system, a spacecraft functionally emulating the prototype servicing architectures of both a NEXTSat serviceable satellite and a commodity payload, and ground facility support), a program Risk Assessment / Risk Mitigation Plan, a Technology Development Plan, an on-orbit Demonstration Concept, and a demonstration Detailed Test Plan. In addition, each team will define a detailed approach for performing the final design and fabrication of the Demonstration System in Phase II.

Each team will also develop a preliminary Orbital Express Transition Plan (OETP) defining the full set of operational evaluations, technology and manufacturing process developments, and risk reduction activities envisioned to be necessary following completion of the ATD to support a Defense Acquisition Board (DAB) Milestone II decision to initiate an Orbital Express acquisition program, and enter Engineering and Manufacturing Development (EMD). In so doing, each team will clearly distinguish between those activities they envision to be part of their Phase II effort and other technology and process maturation or risk reduction activities envisioned to be conducted outside their ATD Phase II program. Those outside activities must not be critical to the success of the Orbital Express ATD program.

2.4.2 Phase II: Final Design, Fabrication, and On-Orbit Demonstration

Phase II of the Orbital Express ATD program will be devoted to completing system development of the Demonstration System, and ultimately conducting an on-orbit test of the Orbital Express Demonstration System. The Phase II team will complete the Demonstration System detailed design (i.e., the prototype satellite-to-satellite interface, the ASTRO servicing spacecraft's prototype Auto-GN&C system, a prototype ASTRO servicing spacecraft, a spacecraft functionally emulating the prototype servicing architectures of both a NEXTSat serviceable satellite and a commodity payload, and ground facility support); continue risk reduction R&D activities; develop, fabricate, integrate and space-qualify the OEDS; support spacecraft / launch vehicle integration; arrange ground facility support for on-orbit test operations; and, conduct an on-orbit satellite servicing demonstration using the prototype Demonstration System to perform multiple satellite servicing cycles involving automated satellite-to-satellite transfers of fluids and hardware.

The Phase II team will be encouraged to build the Demonstration System as close to the Operational System as feasible. At a minimum, the Demonstration System shall incorporate: 1) the prototype Operational System satellite-to-satellite interface (for the ASTRO servicing spacecraft, the NEXTSat serviceable satellite, and a commodity payload) to enable multiple satellite servicing cycles involving automated satellite-to-satellite transfers of both fluids and hardware; and, 2) the ASTRO servicing spacecraft's prototype Auto-GN&C system.

The Government considers delivery of non-proprietary, fully documented preliminary (Phase I) and final (Phase II) specifications of the satellite-to-satellite mechanical and electrical interfaces used in the OEDS, together with source code and full documentation for all enabling software, and specification of associated protocols (e.g., communications, satellite states and modes, etc.), to be a specific objective of the Orbital Express ATD. The satellite-to-satellite interface preliminary and final specifications, enabling software and associated protocols must be delivered to the Government free of restriction on their use or further distribution.

During Phase II the team will continue to refine their Operational System cost effectiveness analysis and life-cycle cost analysis, their on-orbit Demonstration Concept, their demonstration Detailed Test Plan, and their Orbital Express Transition Plan.

The Orbital Express ATD on-orbit demonstration will be conducted in FY04. It will validate the technical feasibility of automated satellite servicing, and will demonstrate the key technologies for satellite-to-satellite servicing interfaces for both fluid and hardware transfers and an spacecraft Auto-GN&C system enabling autonomous satellite servicing operations.

At the end of Phase II, residual on-orbit OEDS hardware will be transitioned to the Air Force to support follow-on risk reduction and operational evaluation activities described in the Orbital Express Transition Plan. Therefore, the Orbital Express ATD should be planned in a manner that will facilitate a seamless transition to the operational assessments and risk reduction activities believed necessary to support a Defense Acquisition Board (DAB) Milestone II decision to initiate an Orbital Express acquisition program, and enter EMD.

2.5 Management Approach

DARPA is responsible for overall management of the Orbital Express ATD, including technical direction, acquisition, and security. The DARPA Program Manager is responsible for implementing a streamlined approach to program management. Major tenets of that approach include: close cooperation between Government and teams; small staffs; abbreviated oversight; face-to-face communication; real-time decision making; emphasis on solving problems instead of assigning blame; and short, direct lines of authority.

DARPA will obtain expert technical assistance from its System Engineering and Technical Assistance (SETA) contractors, Federally Funded Research and Development Centers (FFRDCs), the national laboratories, and select contractors -- all of whom will have formally declared their intention not to compete as a Phase I/II team member, and will have accepted Organizational Conflict of Interest (OCI) restrictions on their activities and executed appropriate Nondisclosure Agreements (NDAs).

2.6 Other Transaction Agreements

The DARPA Orbital Express ATD program will be executed as an "Other Transaction for Prototypes," using DARPA's authority under Section 845, National Defense Authorization Act for Fiscal Year 1994, as amended. This allows the offeror to be creative in designing the system and in the selection of the management framework which best suits the proposed technical and management approach. The Government will share information and data throughout the program. However, the data will always be advisory, not directive in nature, and offered as a way to foster better communications on the program. Our intent is to provide the best possible insight into what the Government thinks while minimizing oversight. To this end, the Government will focus on accurately defining WHAT is wanted, and let the offeror determine HOW best to provide it. Government oversight will be provided through the same management framework proposed by the offeror.

The Government will allow the offeror to use either commercial or DoD streamlined processes, reporting and management practices. The use of Other Agreement Authority requires compliance with applicable laws but allows the latitude to depart from federal and DoD procurement law, specifically the Federal Acquisition Regulations (FAR) and Department of Defense FAR Supplement (DFARS), and DoD practices. The offeror should take full advantage of this latitude to propose innovative / revolutionary approaches to team building, and to employ other innovative business practices. (DARPA requests each offeror detail how an Orbital Express Section 845 "Other Transaction for Prototypes" agreement (if awarded to your team) will contribute to a broadening of the technology and industrial base available for meeting Department of Defense needs, and how an Orbital Express Section 845 "Other Transaction for Prototypes" agreement (if awarded to your team) will foster new relationships and practices that support the national security of the United States. See Appendix B.) The resulting offeror proposal must clearly demonstrate a robust method to assure and control costs, quality, reliability, system engineering, program schedule, system design, and test planning and execution.

Commercial, industrial, and corporate specifications and standards should be used in lieu of military specifications and standards where appropriate. Military specifications and standards, if needed, should be used as guides, with any modifications, tailoring or partial application described. A rigorous formal process should be employed to design and implement software.

2.7 Funding

DARPA anticipates having $90M available to fund the entire Orbital Express ATD program. It is anticipated that competitive agreements will be awarded to two or more teams for the 14-month Phase I effort. A total of $6.0M is anticipated to be available to fund each Phase I team. One team will be selected to complete the 38-month Phase II effort. It is anticipated that DARPA will award agreements for both Phase I and Phase II using DARPA's authority under Section 845, National Defense Authorization Act for Fiscal Year 1994, as amended. Offerors are encouraged to propose innovative, value-added use of this acquisition mechanism. We expect the offeror to provide a realistic proposal for best achieving the program objectives within the outlined budget and schedule.

2.8 Orbital Express Research and Development Strategy

The DARPA Orbital Express ATD supports the objective of the Department of Defense to increase the effectiveness and efficiency of national security space operations. Consistent with that objective, we are striving to determine the technical feasibility, operational utility, and affordability of an Orbital Express system performing routine, autonomous satellite servicing in the post-2010 timeframe.

An ATD cannot provide solutions for all the questions that must be answered before entering into an acquisition program at the EMD phase. An additional period of risk reduction and operational evaluation activities must be conducted. In order to seamlessly transition from the ATD into this next stage of development we are advocating the Orbital Express acquisition strategy shown in Figure 2.1, and are asking the industry teams to help define those ATD follow-on risk reduction and operational evaluation efforts in their Transition Plan. This post-ATD phase of Orbital Express research, development, and test and evaluation will provide an opportunity to validate and demonstrate technologies matured in parallel with the ATD while performing a series of operational evaluations. The flexibility to seamlessly transition from ATD to EMD will play a key role in compressing the time required to transition new technologies into effective and affordable weapon systems for the warfighters.

3.0 Phase I Statement of Objectives

This section outlines the Government's objectives for Phase I, Concept Definition and Preliminary Design, for the Orbital Express ATD program. The specific objectives of Phase I are to identify and define the requirement for on-orbit satellite servicing, perform utility, cost effectiveness and life-cycle cost analysis, identify a baseline satellite servicing mission, refine an Operational System Concept, define a satellite servicing CONOPS, initiate risk reduction R&D activities, design an Orbital Express Operational System (OEOS), and complete preliminary design of an Orbital Express Demonstrator System (OEDS) that will validate the team's OEOS design and concept of operations to convince both the user and technical communities that the potential benefits of developing and conducting a OEDS satellite servicing demonstration in space provide sufficient value to the Government to justify investing in Phase II. Phase I activities must also clearly demonstrate that the proposed ATD program can be accomplished within the proposed cost and schedule.

3.1 Overview

Teams will implement a complete systems engineering process to satisfy the objectives of the Orbital Express ATD. The major Phase I activities represent a progression from the Operational System Concepts of the industry teams, to their Operational System conceptual designs, to identification of critical technologies, and finally, to their development of Demonstration System preliminary designs. Teams will implement their Risk Assessment / Risk Mitigation Plans and identify (and link) additional Phase II Orbital Express ATD technology maturation activities with the appropriate program milestones. They will then use this information to develop an Orbital Express Transition Plan, which address all the technology maturation, demonstration, development activities and operational evaluations necessary to support a decision to transition the ATD into an EMD program.

System analyses, studies, and Operational System engineering design shall address the Government System Capability Document (SCD), Orbital Express ATD program objectives, and the specific instructions below. Studies and analyses performed during this phase shall be documented and accomplished in accordance with the Integrated Master Plan (IMP). Industry teams will be responsible for considering all systems associated with the Operational System, including the satellite-to-satellite servicing interface, the ASTRO servicing spacecraft's Auto-GN&C system, the ASTRO servicing spacecraft, the servicing architectures of both the NEXTSat serviceable satellite and a commodity payload, ground facility support, and system test and evaluation, to a level of detail necessary to justify their Operational System conceptual design, ATD program plan, and transition plan. Phase I analyses, trade studies, and risk reduction activities will be documented and accomplished in accordance with the IMP.

We do not anticipate the Orbital Express Operational System conceptual design to be defined to the level of a traditional federal or DoD procurement program. However, sufficient detail must be provided to enable the team to use the Operational System as the primary filter in selecting the integrated set of critical technologies that will undergo initial risk reduction during Phase I and further development and demonstration during Phase II. The Operational System conceptual design must also be sufficiently detailed to allow identification of the full set of Transition Plan technology maturation or risk/cost reduction activities to be conducted following the ATD program. Those transition activities, while not critical to the success of the current ATD, are critical to an EMD decision.

Phase I results will serve as the foundation and roadmap for achieving the Orbital Express ATD vision and objectives during Phase II. A team's Operational System Concept, CONOPS, Operational System conceptual design and Demonstration System preliminary design, Transition Plan, and results of their other Phase I activities will serve, in part, as evaluation factors for award of the Phase II effort.

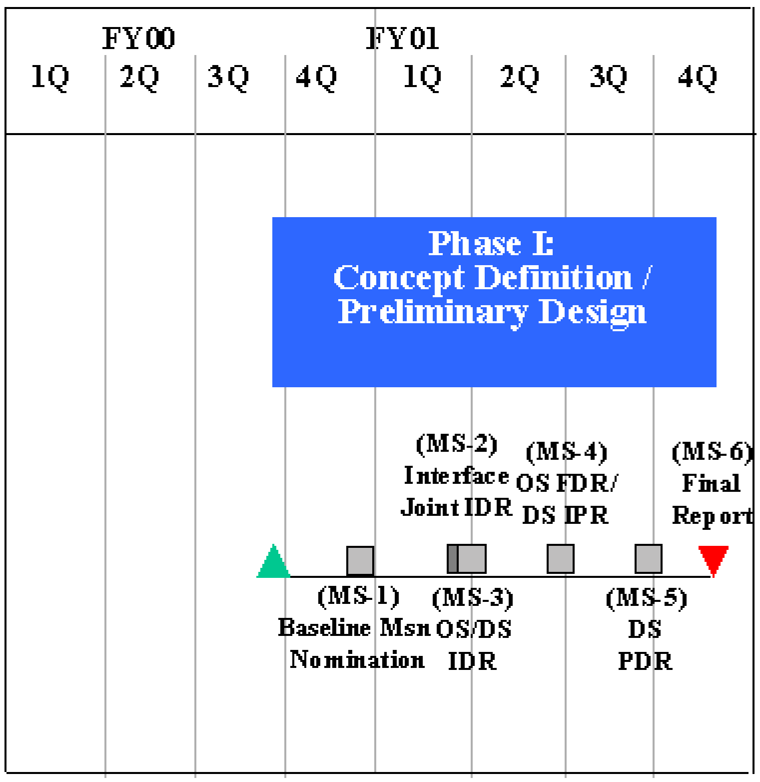

Figure 3.1: Notional Phase I Milestones

3.2 Milestones

DARPA envisions six Phase I milestones. The fifth milestone (Demonstration System PDR) should occur before the end of the twelfth month of Phase I to allow the Government to minimize the time between completion of Phase I and start of Phase II. At a minimum, at each milestone each team must provide the following information and demonstrate the listed accomplishments:

- **Milestone 1** (within 3 Months After Award (MAA))

- Deliverables:
    - Satellite failure mode analysis and systems / components obsolescence analysis
    - OEOS mission utility / requirements analysis
    - Refined Operational System Concept (OSC)
    - Preliminary OEOS cost effectiveness, methodology, trade studies and analysis
    - Preliminary OEOS life-cycle cost, methodology, trade studies and analysis
    - Preliminary ATD Risk Assessment / Risk Mitigation Plan
    - Preliminary ATD Technology Development Plan
    - Baseline ("Design-To") servicing mission nomination and trade studies
- Accomplishments - Information presented demonstrates:
    - Expertise in space system engineering and design
    - Thorough understanding of space system failure modes and obsolescence
    - Thorough knowledge of space missions and CONOPS
    - Sound Operational System Concept
    - VV&A of space system performance and space mission models
    - Thorough understanding of key life-cycle cost, cost-effectiveness and operational effectiveness issues and trades
    - VV&A of cost models
    - Credible life-cycle cost and cost effectiveness results
    - Understanding of key enabling technologies and their maturity

- **Milestone 2** (within 6 MAA)
    - Deliverables:
        - Satellite servicing interfaces joint Initial Design Review (IDR)
    - Accomplishments - Information presented demonstrates:
        - Mechanical and electrical interfaces Specification (together with source code and full documentation for all enabling software, and specification of associated protocols (e.g., communications, satellite states and modes, etc.) consistent with the interface guidance provided at the System Requirements Review (SRR)

- **Milestone 3** (within 6 MAA)
    - Deliverables:
        - OSOS Initial Design Review (IDR)
        - OEDS IDR
        - Preliminary satellite servicing CONOPS and supporting trade studies
        - Final OEOS cost effectiveness, methodology, trade studies and analysis
        - Final OEOS life-cycle cost, methodology, trade studies and analysis
        - Final OEOS affordability analysis supporting a DARPA decision on a target price for the Operational System
        - Preliminary on-orbit Demonstration Concept
        - Preliminary demonstration Detailed Test Plan
        - Revised ATD Risk Assessment / Risk Mitigation Plan

        - Revised ATD Technology Development Plan
    - Accomplishments - Information presented demonstrates:
        - Legacy between OEOS and OEDS designs
        - Thorough understanding of OEOS and OEDS design trades
        - Sound OEOS CONOPS
        - Life-cycle cost and cost effectiveness results of suitable rigor and form for presentation to DoD decision makers
        - Sound demonstration concept and preliminary test plan
        - Refined understanding of key enabling technologies and their maturity
        - Progressive development of key enabling technologies

- **Milestone 4** (within 9 MAA)
    - Deliverables:
        - OEOS Final Design Review (FDR)
        - OEDS design In-Process Review (IPR)
        - Final Operational System Concept
        - Final satellite servicing CONOPS and supporting trade studies
        - Final on-orbit Demonstration Concept
        - Revised demonstration Detailed Test Plan
        - Final ATD Risk Assessment / Risk Mitigation Plan
        - Final ATD Technology Development Plan
        - Preliminary Orbital Express Transition Plan
    - Accomplishments - Information presented demonstrates:
        - Level of OEOS design detail is sufficient to validate all aspects of OEDS design
        - Progress toward reducing the risk of key enabling technologies
        - Refinement of OEDS design
        - Thorough understanding of key features of OEDS demonstration concept
        - Refinement of Detailed test Plan
        - Progressive development of key enabling technologies
        - Understanding of key features of ATD Transition Plan

- **Milestone 5** (within 12 MAA)
    - Deliverables:
        - OEDS PDR
        - Final demonstration Detailed Test Plan
        - Final ATD Risk Assessment / Risk Mitigation Plan
        - Final ATD Technology Development Plan
        - Revised Orbital Express Transition Plan
    - Accomplishments - Information presented demonstrates:
        - OEDS preliminary design
        - OEDS preliminary design with direct legacy to final OEOS design, and validates key features of the OEOS

        - Preliminary, Non-proprietary, fully documented mechanical and electrical satellite servicing interface specification, together with source code and full documentation for all enabling software, and specification of associated protocols (e.g., communications, satellite states and modes, etc.)
        - Progressive development of key enabling technologies
        - Refinement of the ATD Transition Plan

- **Milestone 6** (within 14 MAA)
    - Deliverables:
        - Final Phase I report
    - Accomplishments- Information presented demonstrates:
        - Summation of Phase I activities and accomplishments

The ATD milestones call for three levels of informal design review. All reviews, with the exception of the Milestone 2 interfaces joint IDR, will be conducted at the team location. The interfaces joint IDR will be conducted at a Government location. The objective is to convey information and discuss issues, not to generate formal documentation. No written report is required. Information should be presented in PowerPoint 97 electronic slide format. Annotated copies of the slides will be provided to the meeting attendees. The team will forward an electronic copy of the meeting minutes to the DARPA Program Manager within a week of the review. To assist the offeror in determining the anticipated level of effort for each design review, we offer the following definitions:

- Initial Design Review - Results of empirical and parametric methods used to produce a design where external lines are defined, surfaces sized and located, volume estimated, an internal arrangement of major systems has been accomplished, mass has been estimated, system demands have been estimated by parametric means, and performance has been computed.
- In-Process Review - Results of engineering analysis performed to iterate and advance the design yielding a configuration with confident performance and estimated constraints.
- Final Design Review - Configuration performance is optimized throughout and documentation of a baseline can be confirmed. Integrated (synergistic) results of technologies become obvious. The critical technologies are readily identified and their need justified and validated.

Phase I will include one formal design review. A Demonstration System Preliminary Design Review (PDR) will be conducted at Milestone 5. The PDR will be conducted at a team location. This review shall be compatible with the system engineering requirements for a system-level prototype PDR as set forth in the Electronic Industries Alliance (EIA) “commercialized” version of MIL-STD 499B, initially released in December 1994, as EIA Interim Standard (IS) 632 [EIA/IS 632].

The Government anticipates a kick-off meeting and up to two technical interchange meetings (TIMs) prior to Milestone 1, which will held at a team location.

The Government will conduct one System Requirements Review (SRR), two weeks after Milestone 1, to establish the Demonstration System baseline ("Design-To") servicing mission, and to provide guidance for satellite servicing interfaces specification by the industry teams. The SRR will be conducted at a Government location.

To encourage and facilitate team consensus on a single interface specification, the Government will chair at least two servicing interface Technical Interchange Meetings (TIMs) between the SRR and Milestone 2, the interfaces joint Initial Design Review (IDR). The objective of the TIMs is to allow coordination of DARPA objectives and team activities. TIMs will be small meetings without formal documentation. The interfaces TIMs will be non-proprietary, and will be jointly attended by all teams. Each team's concept and design-to-date for the prototype satellite-to-satellite mechanical and electrical interfaces, source code and full documentation for all enabling software, and specification of associated protocols (e.g., communications, satellite states and modes, etc.), will be jointly reviewed in detail and critiqued to facilitate team convergence on a single preliminary ICD for the Orbital Express satellite servicing interface. The servicing interface TIMs and the Milestone 2 interface joint IDR will be conducted at a Government location.

In addition, the Government anticipates conducting at least one TIM between Milestones 3 and 4 and at least one between Milestones 4 and 5. These TIMs will be held at a team location.

3.3 System Design Trades and CONOPS Analysis

Teams shall conduct system design trades and CONOPS analysis that progressively refine their Operational System Concept into a final Operational System conceptual design. **The specifications in the SCD should serve as bounds for the Operational System and are tradable, except for the following:**

- **Unmanned, Autonomous Operation (Auto-GN&C capability)**
- **Non-proprietary Interface**
- **Transfer of fluids**
- **Transfer of Orbital Replacement Units (ORUs)**

Within this design space, teams shall conduct comprehensive trades and analyses to identify and define both the system performance required to accomplish routine, cost-effective, autonomous re-supply and reconfiguration of on-orbit spacecraft and the corresponding suite of critical technologies required to achieve that performance. The trades shall clearly demonstrate how routine, autonomous satellite re-supply and reconfiguration would be accomplished within the DoD space command and control architecture.

3.3.1 Operational Utility Trades and Analysis

Industry teams shall perform the trades, analyses, and modeling and simulation necessary to define the operational utility / operational effectiveness of routine, on-orbit, autonomous re-supply and reconfiguration of U.S. national security spacecraft (preliminary versions of which will be submitted at Milestone 1). These activities shall consider historical satellite failure modes and rates of obsolescence for subsystems / components and their resulting operational degradation. The following issues illustrate DARPA's view of the relevant trade space:

- Potential servicing demand / servicing opportunities (by type, volume, mass and servicing frequency) by orbital inclination and altitude
- Required servicing responsiveness
- Servicing mission duration
- Operational / mission / programmatic implications of servicing-imposed redesign of potential NEXTSat serviceable satellites
- Level of servicing vehicle autonomy
- Servicing spacecraft ground station coordination with other ground command centers / control stations (e.g., for the objective satellite)
- Serviced satellite maneuverability
- Serviced satellite performance recovery with hardware replacement
- Serviced satellite performance enhancement with hardware upgrades
- Servicing spacecraft ground station capability/operations, location, and sizing

3.3.2 CONOPS.

Teams shall perform the trades, analyses, and modeling and simulation to define the Operational System CONOPS (a preliminary version of which will be submitted at Milestone 1). These activities shall consider all aspects of the envisioned automated satellite servicing mission. The following issues illustrate DARPA's view of the relevant trade space:

- Launch of replenishment commodity payloads for rendezvous with servicing spacecraft: to the proximity of the objective / serviceable satellite or to a distant, common commodity payload / servicing spacecraft reception / rendezvous point.
- Strategy for allocating servicing spacecraft by orbital inclination and/or orbital altitude
- Launching GEO-bound satellites "light," without fluid consumables, then supplying fuel and cryogens after achieving a GEO-Transfer Orbit (GTO).
- Use of innovative approaches to further enable ASTRO such as; aero-assisted plane change maneuvers by the servicing spacecraft to transit to / from objective satellites.
- Degree / type of servicing spacecraft supervised autonomy / ground facility interaction or dependency
- Ground facility flight following of in-transit servicing spacecraft
- Servicing spacecraft "safeing" or flight termination
- Terminal disposition / disposal of commodity payloads and servicing spacecraft
- Options for minimizing inadvertent generation of space contaminants / debris due to malfunction of servicing spacecraft or failed servicing attempt
- Servicing spacecraft rendezvous and close approach operations
- Authority of ground facilities of the servicing and serviced spacecraft during close proximity / docked operations
- Dynamic control of docked spacecraft

3.3.3 Satellite Servicing Interfaces

Teams shall perform the trades, analyses, modeling and simulation, and risk reduction tasks necessary to define the configuration, attributes, performance, and life-cycle cost associated with the OEOS satellite servicing mechanical and electrical interfaces, enabling software, and associated protocols (e.g., communications, satellite states and modes, etc.). The following issues illustrate DARPA's view of the relevant trade space:

- Transferable fluid consumables (fluid type / volume / mass / unique properties or handling requirements)
- Transferable hardware upgrades (type / volume / mass / shape / unique properties or handling requirements)
- Fluid / hardware transfer rates
- "Remove-and-Replace" versus "Plug-and-Stay" servicing strategy for hardware upgrades
- Common versus unique interfaces for transfers between on-orbit commodity payloads and ASTRO servicing spacecraft, and between ASTRO servicing spacecraft and NEXTSat serviceable satellites
- Design / redesign implications for the architecture of potential NEXTSat serviceable satellites and on-orbit commodity payloads
- Common versus unique interfaces for transfers of different fluids
- Common versus unique interfaces for hardware transfers of different types
- Implications of docking versus close proximity station keeping
- Environmental vulnerability
- Complexity / reliability / ease of operation
- Mean mission duration

3.3.4 ASTRO Satellite Servicing Vehicle.

Teams shall perform the trades, analyses, modeling and simulation, and risk reduction tasks necessary to define the configuration, attributes, performance, and life-cycle cost of the OEOS ASTRO satellite servicing vehicle and its systems. The following issues illustrate DARPA's view of the relevant trade space:

- Auto-GN&C system characteristics and performance
- Sensor suite type / characteristics and performance
- Power / propulsion characteristics and performance
- Servicing mission instruction set upload (including data on estimated joint dynamics of docked spacecraft)
- Forecast objective satellite configuration and status (including associated supporting spacecraft data) at time of servicing
- In-transit situation awareness demands
- Tracking, Telemetry and Communications (TT&C) requirements / options
- Modes and states during servicing
- Servicing mission timeline / duration
- Servicing vehicle operational envelop (maximum orbital plane change and/or change in orbital altitude per servicing mission / cycle) given characteristics of potential servicing demand

- Transferable payload (fluid type / volume / mass, and hardware upgrade type / number / volume / mass / shape)
- Common vehicle design versus unique vehicle designs for fluid versus hardware servicing, or for re-supply of propellant versus cryogens
- Vehicle size and mass
- Mean mission (on-orbit) duration
- On-orbit maintenance / repair of servicing spacecraft

3.3.5 NEXTSat Serviceable Satellite Architecture.

Teams shall perform the trades, analysis, modeling and simulation, and risk reduction tasks necessary to define the configuration, attributes, performance, and life cycle cost of the OEOS NEXTSat satellite architecture enabling the automated transfer of fluid consumables and hardware component upgrades between a satellite servicing vehicle and a NEXTSat serviceable satellite. The following issues illustrate DARPA's view of the relevant trade space:

- Serviceable satellite implied system design change magnitude / complexity
- Serviceable satellite implied system functional / operational / mission changes
- Reliability / environmental vulnerability implications for serviceable satellite
- Added serviceable satellite functions (e.g., carriage of secondary payloads)
- Serviceable satellite required modes and states during servicing
- "Remove-and-Replace" versus "Plug-and-Stay" hardware upgrades

3.3.6 Supportability.

Teams shall evaluate logistics issues relevant to on-orbit satellite servicing. The following issues illustrate DARPA's view of the relevant trade space:

- Storage and handling of alternative fluid consumables
- Servicing spacecraft replacement rates / on-orbit mean mission duration (MMD)
- Disposal of on-orbit hardware (commodity payloads, servicing spacecraft and replaced/removed ORUs
- On-orbit environmental constraints on servicing operations
- Ground station requirements and operations

3.4 Life-Cycle Cost and Cost Effectiveness Analysis.

Teams shall perform the trades, analyses, and modeling and simulation necessary to define the cost effectiveness and life-cycle cost associated with routine, automated re-supply and reconfiguration of on-orbit spacecraft. Life-cycle cost analyses shall consider a 20-year life-cycle in light of historical experience with satellite failure modes and rates of obsolescence for systems / components. The analyses shall include the cost of development, acquisition, ownership, and disposal. Particular attention will be paid to a through and accurate estimate of all the support costs associated with a team's preferred CONOPS.

Industry teams will provide a process for analyzing system life-cycle cost that allows visibility into, and sensitivity determination of, all key parameters. Teams should also identify all key assumptions and the rationale for their use. All life-cycle cost analyses shall clearly demonstrate the cost sensitivity to variations in key parameters and assumptions. The Government will be supported by independent cost assessments and evaluations, in conjunction with the Phase I Milestones, to verify / validate key cost assumptions and estimates.

The following issues illustrate DARPA's view of the relevant trade space:

- "Repair vs. Replace" satellite capability recovery strategies
- Higher risk tolerance for launch failure for commodity payloads
- Launch cost impact of frequent launches of lower-value, lower volume, lower mass commodity payloads
- Required enabling launch cost for commodity payloads

3.5 Figures of Merit

In order to facilitate all the previously defined trade studies and analyses, and provide a fair basis for comparison between / among teams, the mission effectiveness and affordability of the Operational System should be measured against an identical set of defined criteria, or figures of merit. At a minimum, teams should use the following figures of merit during Phase I:

- **Mission effectiveness**:
  - Increased percentage of operationally fully capable NEXTSat serviceable satellites
  - Increased percentage of primary mission / function available
  - Increased percentage of secondary mission / function available due to non-necessity to restore lost primary mission functionality
  - Responsiveness / timeliness of space system / mission support
  - Quality of space system / mission support

- **Affordability**:
  - 20-year OEOS system life-cycle cost (LCC)
  - 20-year savings attributable to satellite servicing (i.e., avoided mission opportunity cost due to degraded / lost functionality, avoided mission cost of circumventing / replacing lost functionality, and avoided mission costs associated with otherwise having to launch additional or upgraded satellites to satisfy operational requirements)
  - OEOS life-cycle cost benefit (attributable savings less OEOS LCC)

The offeror may suggest alternative figures of merit in their Phase I proposal. The Government anticipates the figures of merit will be refined and finalized within the first two months of Phase I.

3.6 Orbital Express Transition Plan

Industry teams shall develop their initial Orbital Express Transition Plan to provide the Government with the fiscal and technical information necessary to develop an acquisition strategy that supports the USAF Long-Range Plan. The Transition Plan should describe all the additional risk reduction, technology and process development and maturation, and operational evaluation activities that are outside the scope of the ATD program, but must be conducted prior to entering into an acquisition program at the EMD phase. All Operational System technologies and functionality not incorporated in the Demonstration System shall be addressed in the Transition Plan. The Transition Plan should leverage to the extent possible on-going and planned Government and industry space programs, and include appropriate cost and schedule information. The Transition Plan will be a living document that is updated and refined throughout Phase II.

3.7 System Test

Teams shall develop a demonstration Detailed Test Plan that will govern their on-orbit test and evaluation of the Demonstration System, as well as their tests and evaluations of technologies critical to an Orbital Express Operational System performing routine, autonomous satellite servicing in the post-2010 timeframe. This test plan shall include (but is not limited to) Phase I technology risk reduction tests and critical technology evaluation events, Phase II technology risk reduction tests and critical technology evaluation events, system and component verification, OEDS space qualification, and OEDS on-orbit check-out and demonstration events. The test plan will address the role of modeling and simulation in both planning and conducting the test program. Innovative methods for test and evaluation should also be discussed.

Test location, method and major test parameters are to be identified and shall include any proposed requirements for Government test facilities or resources. The DARPA Program Manager will discuss and evaluate the proposed use of Government resources with the industry teams, and if agreement is reached, will attempt to facilitate team efforts to arrange for their use/availability. Cost for the proposed use of Government facilities/resources shall be included in each team’s Phase I and Phase II proposals. The content of the Demonstration System Detailed Test Plan, and the extent to which it meets the objectives of the Orbital Express ATD program, will be considered in the Phase II selection process.

4.0 Proposal Guidance

This section of the solicitation provides the offeror guidance for the development of a unique Operational System Concept (OSC), Task Description Document (TDD), Integrated Master Plan (IMP) and Integrated Master Schedule (IMS). These documents will be inserted into the Model Agreement (Section 6), and form the basis for the offeror's proposal in response to the Orbital Express ATD Phase I solicitation.

The guidance contained in this section applies to Phase I of the Orbital Express ATD program. It is anticipated that these instructions will evolve as the Orbital Express ATD program matures, and will be updated with the Phase II solicitation. The instructions are not intended to be all-inclusive, but should be considered as each offeror develops their proposal.

4.1 Work Outline

This notional Work Outline describes the program structure outline as viewed by DARPA. It provides a common numbering system that ties all program elements together. The offeror is free to propose their own Work Outline. This numbering system, or an alternative proposed by the offeror, will be used throughout all program documentation. In particular, the offeror must ensure that the numbering system used integrates the OSC, TDD, IMP, and IMS. As the program progresses, this same outline shall be used to define the Orbital Express Operational System (OEOS) and the Orbital Express Demonstration System (OEDS). To allow for an equitable comparison of competing concepts, the offeror shall ensure their Work Outline addresses all the program elements shown below:

Outline Code	**Level 1**	**2**	**3**	**4…**
00000	Orbital Express System			
10000		Mission Analysis		
			On-Orbit Servicing Utility	
			Operational System Concept	
			CONOPS	
20000		Life-Cycle Cost and Cost Effectiveness Analysis		
			Life-Cycle Cost	
			Cost Effectiveness	
30000		ASTRO Servicing Vehicle		
			Spacecraft Bus	
			Auto-GN&C System	
			Command, Data Handling and Processing System	
			Servicing Mission Instruction Set	
			Servicing Modes and States	

Sensor System
Power and Power Distribution System
Propulsion System
Tracking, Telemetry and Communications System
Fluid Payload Storage and Handling
Hardware Payload Storage and Handling
Longevity / Durability
Environmental Survivability
Integration and test
Disposition / Disposal

40000 Satellite Servicing Interface
Mechanical Interfaces
Electrical Interfaces
Enabling Software
Associated Protocols
Tools / End Effectors
Longevity / Durability
Disposition / Disposal

50000 NEXTSat Serviceable Satellite Architecture
Spacecraft Bus
Command, Data Handling and Processing System
Cooperative Servicing Aids System
Servicing Modes and States
Fluid Consumables Receipt and Handling
Hardware Receipt
Power and Power Distribution System
Propulsion System
Tracking, Telemetry and Communications System Environmental Survivability
Integration and test
Longevity / Durability
Disposition / Disposal

60000 Commodity Payload
Spacecraft Bus
Command, Data Handling and Processing System
Cooperative Servicing Aids System
Payload Transfer Modes and States
Fluid Consumables Payload Storage, Handling and Transfer
Hardware Payload Storage, Handling and Transfer
Power and Power Distribution System
Propulsion System
Tracking, Telemetry and Communications System Environmental Survivability
Integration and test
Longevity / Durability
Disposition / Disposal

70000 MicroSatellite

- Spacecraft Bus
- Command, Data Handling and Processing System
- Cooperative Servicing Aids System
- Payload Transfer Modes and States
- Fluid Consumables Payload Storage, Handling and Transfer
- Hardware Payload Storage, Handling and Transfer
- Power and Power Distribution System
- Propulsion System
- Tracking, Telemetry and Communications System Environmental Survivability
- Integration and test
- Longevity / Durability
- Disposition / Disposal

80000 Ground Facility Support

- Facility
- Coordination / Use Agreements
- Hardware / Software Modifications
- Mission Planning
- Executive-Level Mission Management
- Command, Data Handling and Processing System
- Tracking, Telemetry and Communications System
- Manpower, Personnel & Training
- Security

90000 Supportability

- Reliability & Maintainability
- Maintenance Planning
- Launch Support Equipment
- Manpower, Personnel & Training
- Supply Support
- Safety & Health Hazards

100000 Systems Engineering/Program Management

- Systems Engineering Management
- System Integration
- System Software Development Process
- Manufacturing and Production Planning
- Human Factors
- Specialty Engineering
- Program Management
- Configuration Management
- Financial Management

110000 System Test

- Test Planning
- Risk Reduction
- Systems Integration and Test
- Space Qualification

On-Orbit Checkout
Test Evaluation
Test Resources

4.2 Organization

The offeror shall use the following outline in response to this solicitation.

- Executive Summary
- Technical Approach and Substantiation (This shall include the Operational System Concept (OSC))
- Past Performance
- Proposed Agreement with Attachments
    - Task Description Document (TDD)
        - Trade Study and Analysis Plan
        - Risk Assessment and Mitigation Plan (RAMP)
        - Demonstration System Design Plan
        - Systems Engineering/Program Management
    - Integrated Master Plan (IMP)
        - Product IMP
        - Process IMP
- Integrated Master Schedule (IMS)
- Cost Response
- Section 845 “Other Transaction for Prototypes” Questionnaire Response
- Classified Sensitive Compartmented Information (SCI) Annex (as appropriate)

4.3 Executive Summary

This document is meant to be an executive level description of key elements and unique features of each offeror’s proposed Orbital Express ATD Phase I program. The Executive Summary should at least address the offeror's:

1) Program Objectives and Approach
2) Acquisition Approach, including schedule, technical performance risk areas, risk mitigation or reduction activities, and leveraging from Independent Research and Development (IR&D) or other Government research activities
3) Top-Level Program Schedule
4) Proposed Cost

4.4 Technical Approach and Substantiation

This section of the proposal provides offerors the opportunity to explain and substantiate the significant features of their OSC, trade study and analysis plan, RAMP, and overall technical approach and management plan. The offeror should provide significant details to address all the relevant evaluation criteria outlined in Section 5.

4.5 Past Performance

This section of the proposal provides offerors the opportunity to describe past performance of relevant activities that substantiates their ability to successfully complete both Phase I and Phase II of the Orbital Express ATD program. In describing their relevant past performance, offerors should be particularly attentive to identify past or present activities that evidence the capability of team members designated in the proposal as the designers and manufacturers of each of the two major Demonstration System subsystems (see Section 1.2.3); and, the offeror's capability to design and produce the ASTRO servicing spacecraft's prototype Auto-GN&C system (see Section 1.2.4). The offeror shall provide detailed past performance information as specified in Section 5.

4.6 Task Description Document (TDD)

Based on the guidance in this section, the offeror shall prepare a TDD that describes the work effort necessary to meet the milestones and Statement of Objectives for Phase I of the Orbital Express ATD program. The TDD will include the offeror's plans for: trade studies and analyses, risk mitigation, OEDS design, and systems engineering/program management. This guidance identifies work effort to Level 3 of the Work Outline. The offeror may choose to define work at lower levels to better explain their approach toward meeting program and system objectives. The TDD will be incorporated into the offeror's proposed Agreement.

4.6.1 Trade Study and Analysis Plan

The trade study and analysis plan shall describe the offeror's approach to progressively refining their OSC into a final OEOS design. Those refinements will be based on a series of CONOPS and system design trades as discussed in section 3.3. The specifications in the System Capability Document (Appendix A) should serve as bounds for the OEOS.

4.6.2 Risk Assessment and Mitigation Plan

As part of their Phase I proposal, the offeror will include a Risk Assessment and Mitigation Plan (RAMP) in their TDD. The RAMP will identify the key technical risk areas in the OSC and provide a roadmap of critical Phase I risk reduction activities. The plan shall include a process for quantifying the maturity, risk, system performance enhancement/value, and life-cycle cost reduction benefits of candidate technologies. At a minimum, the RAMP should identify:

- The type of risk reduction activity required to validate the technologies (e.g., simulation)
- The cost and schedule required to mature these technologies
- The cost and schedule required to mature critical manufacturing processes
- The fallback technologies and processes that would be implemented if the maturation activities were unsuccessful.

4.6.3 Demonstration System Design Plan

The Demonstration System design plan will identify the top-level metrics, processes, and system-level performance and affordability trades the offeror intends to use to select the critical technologies validated by their Demonstration System. The offeror is encouraged to take full advantage of emerging collaborative design methodologies and advanced modeling and simulation tools. The Demonstration System shall be designed to validate the critical technologies and satisfy the ATD objectives in a system with direct legacy to the OEOS. Ideally the Demonstration System design should incorporate the same subsystem integration and shape, volume and mass as the OEOS. The Demonstration System should be capable of supporting the exploration of the full range of Orbital Express ATD. The ground facility supporting the demonstration should be capable of supporting the exploration of the full range of Orbital Express ATD objectives. The plan will also consider the use of Government Furnished Equipment (GFE). Additional guidance will be provided after Milestone 1 to help the offerors refine their Demonstration System preliminary design.

4.6.4 Systems Engineering / Program Management

The offeror shall describe a complete systems engineering process for conducting Phase I and II of this program which is consistent with the framework defined in the Electronics Industries Alliance (EIA) Interim Standard (IS) 632 [EIA/IS 632]. Their description shall describe how they will execute the systems engineering process activities of requirements analysis, functional analysis and allocation, synthesis, and systems analysis and control commensurate with the statement of objectives. The offeror shall describe the organizational responsibilities and authority for the systems engineering effort, including control of team member engineering. Similarly, a program management process based on the concepts of Integrated Product and Process Development (IPPD) shall be established. The offeror shall integrate their systems engineering and program management processes to ensure the program progresses successfully through the Phase I milestones. This process should establish a series of tracking tools, which should be updated monthly and shall include:

- Technical Performance Measures (TPM): The offeror should provide a series of TPMs which track the maturity of key program technical parameters and provide management indicators that forecast the achievement of program objectives. The offeror should initially develop TPMs that delineate key technical goals and objectives through Level 2 of the Work Outline. Metrics should be developed for systems engineering, program management and test and evaluation. Example TPMs are OEOS performance parameters and system life-cycle costs.
- IMS: The offeror will establish and maintain a master scheduling system that complements the IMP and provides continuous status of program accomplishments against time. This tiered system will provide visibility to Work Outline Level 3 and Level 4 items, as appropriate.
- Financial Management System: The offeror will provide a financial management system that allows the Government on-line visibility into their program budget and spend plan and is tied to their work outline.

- System Software Development Process: The offeror will implement and maintain a rigorous formal process for software development and integration that follows an established military, national, or international standard.

4.7 Integrated Master Plan (IMP). The offeror shall develop a comprehensive IMP, in contractor format, that describes Phase I of the Orbital Express ATD program. The IMP is divided into the Product IMP and the Process IMP. Both the Product IMP and Process IMP for Phase I should be provided to the Government as an attachment to the offeror's proposed Agreement.

4.7.1 Product IMP. The Product IMP shall address specification, verification, and significant management accomplishments necessary to complete the requirements analyses, design trade studies, and risk reduction activities for Phase I. The Product IMP should contain, accomplishments/criteria sections tied to the Work Outline (section 4.1) and program milestones (section 3.2). Each task will be accompanied by specific criteria that will be used to judge the completion of the task for a given milestone. Definitions and characteristics of the key elements of the IMP are given below:

Significant Accomplishment:

- Desired result at a specified event that indicates a level of design maturity or progress directly related to each product / process.
- Discrete step in the progress of the planned development.
- Describes functional interrelationships of different disciplines applied to the program (e.g. test, manufacturing, system engineering).
- Must be event related, not solely time related

Event

- The conclusion / initiation of an interval of major program activity.
- Decision oriented maturation events.
- Events need not be sequential.
- Number of events should increase for lower levels.

Phase I milestone criteria were provided in section 3.2.

4.7.2 Process IMP. The Process IMP is used to describe the technical, management, systems engineering, and business processes the offeror plans to apply to the Orbital Express ATD program. The Process IMP will fulfill the role of functional plans (QA, Configuration, etc.) and will be an essential part of the Agreement and address:

- Statement of Objectives
- References - The offeror may propose his existing internal procedures and systems
- Approach - This section should describe what the offeror will do, how the offeror will interface with DARPA, and how they will meet the objectives of the program

4.8 Orbital Express Operational System Concept (OSC).

The offeror's OSC will serve as a point of departure for all subsequent Phase I design and CONOPS trade studies. For the development of the OSC the offeror shall use the System Capability Description (SCD), provided in Appendix A, as guidance to bound the design space. The offeror's OSC description shall conform to the single, common program numbering system outlined in their TDD.

4.9 Integrated Master Schedule (IMS). The IMS should outline the detailed tasks and the amount of time expressed in calendar schedules necessary to achieve the milestones and significant functional accomplishments in Phase I. It is a tiered scheduling system corresponding to the Orbital Express ATD work outline. The first iteration of the IMS should be to Work Outline Level 3, or lower, of the offeror's TDD, as determined by the offeror. Definitions and characteristics of the key elements of the IMS are given below.

<u>Detailed Tasks</u>: Detailed work effort to be completed in support of a specific significant milestone or functional accomplishment.

<u>Calendar Schedule</u>: Detailed schedule (dates) of the period of performance for each work effort.

An initial IMS shall be delivered with the Phase I proposal.

4.10 Section 845 "Other Transaction for Prototype" Questionnaire Response

Responses to questions stated in Appendix B should detail how an Orbital Express Section 845 "Other Transaction for Prototypes" agreement (if awarded to your team) will contribute to a broadening of the technology and industrial base available for meeting Department of Defense needs, and how an Orbital Express Section 845 "Other Transaction for Prototypes" agreement (if awarded to your team) will foster new relationships and practices that support the national security of the United States. Your response will, in part, form the foundation of a DARPA report to DoD and Congress. Responses are to be provided in the offeror's format.

4.11 Cost Response

The cost response is to be provided in the offeror's format. Certified cost or pricing data is not required. However, in order for the Government to determine the reasonableness, realism and completeness of your cost proposal, the following data must be provided for each team member and in a cumulative summary:

<u>Labor</u>: Total labor includes direct labor and all indirect expenses associated with labor, to be used in the Orbital Express ATD Phase I period of performance. Provide a breakdown of labor and rates for each category of personnel to be used on this project.

<u>Direct Materials</u>: Total direct material that will be acquired and/or consumed in the Orbital Express ATD Phase I period of performance. Limit this information to only major items of material and how the estimated expense was derived.

Subcontracts: Describe major efforts to be subcontracted, the source, estimated cost and the basis for this estimate.

Travel: Total proposed travel expenditures relating to the Orbital Express ATD Phase I period of performance. Limit this information to the number of trips, and purpose of each cost.

Other Costs: Any direct costs not included above. List the item, the estimated cost, and basis for the estimate.

Remember the cost proposal should tell the story of how and why you are planning to complete your proposed TDD. Activities such as demonstrations required to reduce the various technical risks should be identified in the TDD and reflected in the cost proposal.

The offeror should provide a total estimated price for the major IR&D activities associated with the program. The offeror should state whether each program is a dedicated IR&D or if it is being pursued to benefit other programs as well.

4.12 Classified Sensitive Compartmented Information (SCI) Annex

Teams are required to contact the DARPA Director of Security and Intelligence, at (703) 696-2385, for complete instructions prior to submitting any classified information.

4.13 Administrative Instructions

Complete the proposed agreement per guidance found in Sections 3 (Phase I Statement of Objectives) and Section 6 (Model Agreement). Articles I, III and IV, and Attachments 1 and 2 are critical in the construction of your response and in the evaluation process. In addition, propose any changes, additions, or deletions to the Model Agreement that should be considered during Agreement negotiations. Fully explain the rationale for the changes made in an addendum to the Agreement. Rationale located in other areas of the solicitation response may be cross-referenced.

4.13.1 Page and Print Information

The Solicitation Response should be submitted in standard three-ring, loose-leaf binders with individual pages unbound and printed single-sided to facilitate copying and page changes. The response shall not exceed 90 pages total, including the SCI Annex (if appropriate). All submittals (other than the Resumes of Key Personnel, Proposed Agreement with Attachments, and the Section 845 Questionnaire Response) shall be included in the 90-page limit. Ten copies shall be provided. The suggested page limits for each section are as follows:

1) Executive Summary	5 pages
2) Technical Approach and Substantiation	40 pages
3) Resumes of Key Personnel (Program Manager and Technical Lead for Each Team)	No limit
4) Past Performance	5 pages

5)	Proposed Agreement with Attachments (exclusive of TDD)	No limit
6)	Task Description Document (TDD)	15 pages
7)	Integrated Master Schedule	5 pages
8)	Cost Response	10 pages
9)	Section 845 Questionnaire Response	No limit
10)	SCI Annex (if appropriate)	10 pages

Proposal volumes must be signed by authorized representatives of the offeror.

Each page should be printed on an 8-1/2" x 11" sheet using Times New Roman 12 point font. Foldout pages are NOT to be used. **Pages shall be prominently marked to ensure classified or proprietary information is properly controlled.**

Teams are required to submit their Proposed Agreement in Microsoft Office 97 compatible electronic format. Teams are also requested to provide graphics (drawings, charts, photos, etc.) contained in their proposal in Microsoft PowerPoint 97 electronic format for use in source selection briefings. Acceptable media includes 3.5" diskettes, 100MB ZIP cartridges or CD ROM. **Electronic copies of classified graphics (if any) shall be submitted separately in accordance with instructions in Section 4.12.**

4.13.2 Response Delivery Information

The deadline for receipt of responses is July 11, 2000 at 2:00 PM Eastern Time. Late responses will not be accepted. The delivery address for mailed or hand carried responses is:

Defense Advanced Research Projects Agency (DARPA)
Orbital Express Program
3701 North Fairfax Drive
Arlington, VA 22203-1714
Attn: Contracts Management Office
Solicitation Number: RA00-37

Responses and response modifications (which will only be accepted prior to the deadline for receipt of response) shall be submitted in sealed envelopes or packages to the address shown above and marked with the following information on the outer wrapping:

Offeror's name and return address
The response receipt address above
Solicitation Number: RA00-37
Hour and due date: July 11, 2000, 2:00 PM Eastern Time

4.13.3 Regulations Governing Objections to Solicitation and Award

Any objections to the terms of this solicitation or to the conduct of receipt, evaluation or award of agreements must be presented in writing within ten calendar days of (1) the release of this solicitation, or (2) the date the objector knows or should have known the basis for its objection. Objections should be provided in letter format, clearly stating that it is an objection to this solicitation or to the conduct of evaluation or award of an agreement, and providing a clearly detailed factual statement of the basis for objection. Failure to comply with these directions is a basis for summary dismissal of the objection. Mail objections to the address listed in the proposal delivery information.

4.13.4 Non-Government Experts

The Government intends to use support contractors, plus other independent experts to assist in processing and administering proposals during the Source Selection, and to provide advice relative to selected technical areas. These personnel are restricted by their contract from disclosing information contained in any proposal for any purpose to anyone outside of the Source Selection for this effort. Moreover, all personnel used in this capacity are required to enter into separate Organizational Conflict of Interest/Non Disclosure Agreements to this effect. By submission of its proposal, a team agrees that proposals may be disclosed to these personnel for the purpose of providing this assistance.

5.0 Evaluation Criteria for Award

5.1 Introduction

DARPA plans to award two or more Agreements for Phase I of the Orbital Express ATD program, and anticipates the award of up to three Phase II Agreements (depending on the acquisition strategy pursued), under a separate solicitation based upon Phase I results (see Section 2.4). Only Phase I teams will be eligible to participate in Phase II. (Team leads awarded agreements for Phase I will remain team leads for Phase II, unless another team member is so specified in the team's Phase I proposal. Team composition for Phase II may be fluid, to allow the inclusion of parallel risk reduction performers (see section 1.2.5), if appropriate.) Phase I selection will be accomplished based on a subjective evaluation of proposals as described in this section of the solicitation. There are four specific evaluation criteria, or factors, that will be used: Technical Approach and Understanding the Problem, Management Process and Tools including Past Performance, and Cost. Each offeror's proposal will receive an integrated evaluation by a single multi-functional team. The Government reserves the right to award without discussions.

5.2 Basis for Phase I Award.

Successful Phase I proposals will incorporate a balanced consideration of all four evaluation factors, and provide best value to the Government. Evaluation factors are listed below, but are not in priority order.

5.2.1 Technical Approach and Understanding the Problem

The offeror's Operational System Concept (OSC), Trade Study and Analysis Plan, Demonstration System Design Plan, and Risk Assessment and Mitigation Plan (RAMP) will be evaluated to determine how well they satisfy the objectives of the Systems Capability Document (SCD) and the Orbital Express ATD as a whole. The areas that will be considered under this evaluation factor are listed below, but are not in priority order:

1) To what extent does the offeror's proposal evidence the capability to successfully complete both Phase I and Phase II of the Orbital Express ATD program.

2) Does the offeror's proposal acknowledge the requirement to deliver non-proprietary, fully documented preliminary (Phase I) and final (Phase II) specification of the satellite-to-satellite mechanical and electrical interfaces used in the OEDS, together with source code and full documentation for all enabling software, and specification of associated protocols (e.g., communications, satellite states and modes, etc.), free of restriction on their use or further distribution?

3) Does the offeror’s proposal acknowledge the requirement that the prototype ASTRO servicing spacecraft and the spacecraft functionally emulating the prototype servicing architectures of both a NEXTSat serviceable satellite and a space commodity payload must be designed and manufactured by different team members?

4) To what extent does the offeror’s proposal demonstrate recognition of the importance of the ASTRO servicing spacecraft’s prototype autonomous Guidance, Navigation and Control (Auto-GN&C) system, and show a comprehensive understanding of the autonomous Guidance, Navigation and Control requirements for on-orbit servicing as envisioned by the Orbital Express ATD program?

5) To what extent does the offeror’s proposal show a comprehensive understanding of the operational issues, economics, and technologies associated with on-orbit servicing of satellites?

6) Has the offeror comprehensively defined the range of on-orbit servicing and refueling concepts to be investigated in concept definition studies, and presented a sound systems engineering methodology to be used in conducting those studies?

7) Has the offeror comprehensively defined the operational utility-related analyses and trade studies required to evaluate the on-orbit servicing concepts to be defined?

8) Has the offeror comprehensively defined the cost-related analyses and trade studies required to evaluate the on-orbit servicing concepts to be defined, and do those analyses and trade studies explicitly address the cost effectiveness and life-cycle cost/affordability of the concepts to be defined?

9) Has the offeror presented an effective systems engineering and design methodology for the definition and preliminary design of the OEDS prototype satellite mechanical and electrical interface (including enabling software and associated protocols) required for on-orbit satellite servicing, the prototype ASTRO servicing spacecraft, and a spacecraft functionally emulating the prototype servicing architectures of both a NEXTSat serviceable satellite and a commodity payload?

10) Has the offeror presented effective systems engineering and design methodology for the definition and conceptual design of the OEOS?

11) Has the offeror presented effective systems engineering and design methodology to ensure their Orbital Express Demonstrator System will validate the critical technologies for, and provide a direct legacy to, their OEOS design?

12) Has the offeror addressed the applicability of evolving space, communications, sensor, and other relevant technology to on-orbit servicing, and proposed a plan

having a robust process and suitable metrics for selecting OEOS critical enabling technologies?

13) Has the offeror proposed an effective Risk Assessment and Mitigation Plan to identify and assess program technical risks, and systematically reduce those risks throughout Phase I?

14) Has the offeror proposed a formal software engineering process?

5.2.2 Management Process and Tools.

The offeror’s management and system engineering processes will be evaluated to ensure that overall sound methodologies, representing good management practices, are used to complete all the Phase I activities described in their TDD, IMP, and IMS. Streamlined and innovative business, teaming, and technical management practices are desired.

The areas which will be considered under this evaluation factor are listed below, but are not in priority order:

5.2.2.1 Management Plan.

1) Has the offeror proposed an innovative team approach (as demonstrated in the team’s proposed organization, management, business practices and working arrangements) that will lead to reductions in cost and schedule throughout the program?

2) Has the offeror proposed a Task Description Document (TDD) that will enable comprehensive, effective and efficient performance of Phase I activities?

3) Has the offeror proposed an organization capable of coordinating large efforts, asserting effective management control and supervision of personnel (including team members), and ensuring the quality of deliverables for this effort?

4) Has the offeror substantiated the team leader’s ability to obtain access to U.S. Government Sensitive Compartmented Information (SCI), and have they adequately addressed their team’s capability to perform classified work (if necessary) at classification levels up to and including TOP SECRET/SENSITIVE COMPARTMENTED INFORMATION?

5) To what extent does the offeror’s Integrated Master Plan (IMP) define the efforts that must be accomplished to meet the Phase I Statement Of Objectives?

6) Does the offeror’s Integrated Master Schedule (IMS) depict a realistic, event-driven, time-phased plan to achieve the goals of the IMP and Task Description Document (TDD)?

7) Does the offeror clearly identify a tracking system that will permit sufficient and timely Government visibility to gauge the accomplishment of program objectives?

5.2.2.2 Facilities Capability

1) Has the offeror addressed their modeling and simulation capabilities to perform vehicle design trades, CONOPS assessment, C4I implementations, system effectiveness and life-cycle cost?
2) Has the offeror adequately addressed their capability to fabricate and test scaled models and other hardware components to support proposed risk reduction activities?
3) Has the offeror adequately addressed their capability, under Phase II, to fabricate, integrate, ground test, space qualify and perform on-orbit checkout of OEDS hardware and software, and conduct OEDS on-orbit demonstration test events?
4) Has the offeror adequately addressed their capability to support program security requirements? Has the offeror presented adequate working space that adheres to SCI requirements?

5.2.2.3 Past Performance

The offeror's past performance of relevant activities will be evaluated to judge their ability to successfully complete both Phase I and Phase II of the Orbital Express ATD program. In describing their relevant past performance, offerors should be particularly attentive to identify past or present activities that evidence the following:

- The capability of team members designated in the proposal as the designers and manufacturers of each of the two major Demonstration System subsystems (see Section 1.2.3); and,
- The capability to design and produce the ASTRO servicing spacecraft's prototype Auto-GN&C system (see Section 1.2.4).

The offeror shall provide the following information, in the order specified, for each activity identified:

1) Name of the activity.
2) Contract identification / number
3) Customer name and address
4) Customer point of contact name and telephone number
5) Period of performance
6) Contract value
7) Synopsis of the work performed
8) Relevance to the offeror's ability to perform Phase I and Phase II of the Orbital Express ATD.

5.2.3 Cost

This evaluation factor will focus on the cost realism, reasonableness and cost benefit of the proposed program to achieving the complete set of Orbital Express ATD goals and objectives.

5.3 Basis for Phase II Award.

Only Phase I teams will be eligible to participate in Phase II. Team leads awarded agreements for Phase I will remain team leads for Phase II, unless another team member is so specified in the team's Phase I proposal. Team composition for Phase II may be fluid, to allow the inclusion of parallel risk reduction performers (see section 1.2.5), if appropriate. Prior to Phase II, each Phase I team will be provided updated evaluation criteria defining the basis for award. DARPA currently has two alternative Phase II acquisition strategies under consideration (see Section 2.4). The acquisition strategy to be adopted will be decided during Phase I. Under one alternative, the Government would select one Phase I team to complete Phase II. Under the second alternative, DARPA would attempt to obtain the best solution for the Orbital Express Demonstration System, and would select a specific Phase I team to complete final design, development, integration and test, and space qualification of a specific Demonstration System subsystem: 1) the ASTRO servicing spacecraft's prototype Auto-GN&C system; 2) the prototype ASTRO servicing spacecraft (to include serving as the Phase II team lead, the Demonstration System engineer and integrator (SE&I), and coordinator of ground facility support of on-orbit test operations); or , 3) the spacecraft functionally emulating the prototype servicing architectures of both a NEXTSat serviceable satellite and a commodity payload).

Phase II selection will be accomplished based on a subjective evaluation of proposals in the areas of Demonstration System Capability, Technical Approach, Management Process and Tools, Cost, and the offeror's estimated price for an Orbital Express Operational System. Heavy emphasis will be placed on results and lessons learned from Phase I. New evaluation criteria specific to the Phase II source selection will be provided with the Phase II solicitation.

6.0 Model Agreement

AGREEMENT

BETWEEN

(INSERT NAME AND ADDRESS)

AND

THE DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
3701 NORTH FAIRFAX DRIVE
ARLINGTON, VA 22203-1714

CONCERNING

(INSERT Proposal Title)

Agreement No.: **MDA972-00-9-XXXX**
DARPA Order No.:
Total Estimated Government Funding of the Phase I Agreement: $
Funds Obligated: $
Authority: 10 U.S.C. 2371 and Section 845, National Defense Authorization Act for Fiscal Year 1994, as amended.

Line of Appropriation: AA

This Agreement is entered into between the United States of America, hereinafter called the Government, represented by The Defense Advanced Research Projects Agency (DARPA), and the (INSERT NAME) pursuant to and under U.S. Federal law.

FOR (INSERT CONTRACTOR NAME)	FOR THE UNITED STATES OF AMERICA THE DEFENSE ADVANCED RESEARCH PROJECTS AGENCY
(Signature)	(Signature)
(Name, Title) (Date)	(Name, Title) (Date)

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ARTICLES

ATTACHMENTS

ARTICLE I: SCOPE OF THE AGREEMENT

[This article should state your vision for the Phase I of the Orbital Express Advanced Technology Demonstration (ATD) Program and describe how your proposed program satisfies the Statement of Objectives. This article should summarize the scope of the work you are committing to (as described in detail in Attachment 1, Task Description Document) by entering into this Agreement.

In addition, this article should discuss the way you will interact with the DARPA program team. Suggested wording (paragraphs used in other DARPA Agreements) for your consideration follows:

"DARPA will have continuous involvement with the Contractor. DARPA will obtain access to program results and certain rights to data and patents pursuant to Articles VII and VIII. DARPA and the Contractor are bound to each other by a duty of good faith and best effort in achieving the program objectives."

"This Agreement is an Other Transaction pursuant to 10 U.S.C. 2371 and Section 845, National Defense Authorization Act for Fiscal Year 1994, as amended. The Parties agree that the principal purpose of this Agreement is to stimulate the Contractor to provide best efforts in development even though the acquisition of property or services for the direct benefit or use of the Government is present. The Federal Acquisition Regulation (FAR) and Department of Defense FAR Supplement (DFARS) apply only as specifically referenced herein. This Agreement is not intended to be, nor shall it be construed as, by implication or otherwise, a partnership, a corporation, or other business organization."

This Agreement is not a traditional FAR/DFARS contract. This Agreement can best be described as Fixed Price Best Efforts with payment based upon completion of the milestone accomplishment criteria. Payable milestones with task or performance accomplishment criteria, not strict exit criteria are subject to approval by the Government Program Manager.

Terms such as "Contractor", "parties", "program", etc. should also be defined in this article. Should "Contractor" be a team, alliance, partnership or other arrangement, this article must reflect these provisions and specifically document the relationship between DARPA and the "unique" Contractor arrangement.]

ARTICLE II: TERM

A. Term of this Agreement

The Program commences upon the date of the last signature hereon and continues through completion of the milestone accomplishment criteria and deliverables in Attachment 3. For planning purposes, the estimated period of performance is 14 months for Phase I. Provisions of this Agreement, which, by their express terms or by necessary implication, apply for periods of time other than specified herein, shall be given effect, notwithstanding this Article.

B. Termination Provisions

Subject to a reasonable determination that the program will not produce beneficial results commensurate with the expenditure of resources, either Party may terminate this Agreement by written notice to the other Party, provided that such written notice is preceded by consultation between the Parties. In the event of a termination of the Agreement, it is agreed that disposition of subject inventions and data developed under this Agreement shall be in accordance with the provisions set forth in Articles VII and VIII. The Government, acting through the Agreements Officer, and the Contractor will negotiate in good faith a reasonable and timely adjustment of all outstanding issues between the Parties as a result of termination. Failure of the Parties to agree to a reasonable adjustment will be resolved pursuant to Article VI, Disputes. The Government has no obligation to pay for any milestones to the Contractor, beyond the last completed and paid milestone, if the Contractor decides to terminate.

C. Extending the Term

The Parties may extend by mutual written agreement the term of this Agreement and research opportunities reasonably warrant. Any extension shall be formalized through modification of the Agreement by the Agreements Officer and the Contractor Administrator.

ARTICLE III: MANAGEMENT OF THE PROJECT

A. Management and Program Structure

The Contractor shall be responsible for the overall technical and program management of the Program, and technical planning and execution shall remain with the Contractor. The DARPA Agreements Officer’s Representative shall provide recommendations to Program developments and technical collaboration, and be responsible for the review and verification of the Payable Milestones.

B. Modifications

1. As a result of quarterly meetings, or at any time during the term of the Agreement, research progress or results may indicate that a change in the Agreement would be beneficial to program objectives. Recommendations for modifications, including justifications to support any changes to the Agreement, will be documented in a letter and submitted by the Contractor to the DARPA Agreements Officer’s Representative with a copy to the DARPA Agreements Officer. This documentation letter will detail the technical, chronological, and financial impact of the proposed modification to the research program. The Contractor shall approve any Agreement modification.

2. The DARPA Agreements Officer’s Representative shall be responsible for the review and verification of any recommendations to revise or otherwise modify the Agreement.

3. For minor or administrative Agreement modifications (e.g. changes in the paying office or appropriation data, changes to Government or the Contractor personnel identified in the Agreement, etc.), no signature is required by the Contractor.

ARTICLE IV: AGREEMENT ADMINISTRATION

Administrative and contractual matters under this Agreement shall be referred to the following representatives of the parties:

DARPA, Thomas Lyon, Agreements Officer, Tel: (703) 696-2411

CONTRACTOR:(INSERT NAME)(Contractor Administrator)(INSERT TELEPHONE NUMBER)

Technical matters under this Agreement shall be referred to the following representatives:

DARPA: Samuel B. Wilson III, Program Manager, Tel: (703) 696-2310

CONTRACTOR: (INSERT NAME) (INSERT TITLE) (INSERT TELEPHONE NUMBER)

Each party may change its representatives named in this Article by written notification to the other party. The Government will effect the change as stated in item B.3 of Article III above.

ARTICLE V: OBLIGATION AND PAYMENT

A. Obligation

The Government's liability to make payments to the Contractor is limited to only those funds obligated under this Agreement or by amendment to the Agreement. DARPA may obligate funds to the Agreement incrementally.

B. Payments

1. Prior to the submission of invoices to DARPA by the Contractor Administrator, the Contractor shall have and maintain an accounting system which complies with Generally Accepted Accounting Principles (unless Cost Accounting Systems (CAS) applies) and with the requirements of this Agreement, and shall ensure that appropriate arrangements have been made for receiving, distributing and accounting for Federal funds.

2. The Contractor shall document the accomplishments of each Payable Milestone by submitting or otherwise providing the Payable Milestones Report as required. The Contractor shall submit

an original and one (1) copy of all invoices to the Agreements Officer for payment approval. After written verification of the accomplishment of the Payable Milestone by the DARPA Program Manager, and approval by the Agreements Officer, the invoices will be forwarded to the payment office within fifteen (15) calendar days of receipt of the invoices at DARPA. Payments will be made by Defense Accounting Office, DFAS, Attention: Vendor Pay, 8899 East 56th Street, Indianapolis, IN 46249-1325 within fifteen (15) calendar days of DARPA's transmittal. Subject to change only through written Agreement modification, payment shall be made to the address of the contract's Administrator set forth below.

3. Address of Payee: (INSERT NAME AND ADDRESS OF PAYEE)

4. Limitation of Funds: In no case shall the Government's financial liability exceed the amount obligated under this Agreement.

5. Financial Records and Reports: The Contractor's relevant financial records are subject to examination or audit on behalf of DARPA by the Government for a period not to exceed three (3) years after expiration of the term of this Agreement. The Contractors shall provide the Agreements Administrator or designatee direct access to sufficient records and information of the Contractor to ensure full accountability for all funding under this Agreement. Such audit, examination, or access shall be performed during business hours on business days upon prior written notice and shall be subject to the security requirements of the audited party.

6. In addition, The Comptroller General, at its discretion, shall have access to and the right to examine records of any party to the agreement or any entity that participates in the performance of this agreement that directly pertain to, and involve transactions relating to, the Agreement. Excepted from this requirement is any party to this Agreement or any entity that participates in the performance of the Agreement, or any subordinate element of such party or entity, that has not entered into any other agreement (contract, grant, cooperative agreement, or “other transaction”) that provides for audit access by a Government entity in the year prior to the date of the Agreement.

ARTICLE VI: DISPUTES

A. General

The Parties shall communicate with one another in good faith and in a timely and cooperative manner when raising issues under this Article.

B. Dispute Resolution Procedures

1. Any disagreement, claim or dispute between DARPA and the Contractor concerning questions of fact or law arising from or in connection with this Agreement, and, whether or not involving an alleged breach of this Agreement, may be raised only under this Article.

2. Whenever disputes, disagreements, or misunderstandings arise, the Parties shall attempt to resolve the issue(s) involved by discussion and mutual agreement as soon as practicable. In no event shall a dispute, disagreement or misunderstanding which arose more than three (3) months prior to the notification made under subparagraph B.3 of this article constitute the basis for relief under this article unless the Director of DARPA, in the interests of justice, waives this requirement.

3. Failing resolution by mutual agreement, the aggrieved Party shall document the dispute, disagreement, or misunderstanding by notifying the other Party (through the DARPA Agreements Officer or Contractor Administrator, as the case may be) in writing of the relevant facts, identify unresolved issues, and specify the clarification or remedy sought. Within five (5) working days after providing notice to the other Party, the aggrieved Party may, in writing, request a joint decision by the Special Assistant for Acquisition and Technology and senior executive (no lower than (INSERT A LEVEL OF EXECUTIVE FAR ENOUGH REMOVED FROM THE PROGRAM TO MAINTAIN A GREATER LEVEL OF IMPARTIALITY) level) appointed by the Contractor. The other Party shall submit a written position on the matter(s) in dispute within thirty (30) calendar days after being notified that a decision has been requested. DARPA Special Assistant, and the senior executive shall conduct a review of the matter(s) in dispute and render a decision in writing within thirty (30) calendar days of receipt of such written position. Any such joint decision is final and binding.

4. In the absence of a joint decision, upon written request to the Director of DARPA, made within thirty (30) calendar days of the expiration of the time for a decision under subparagraph B.3 above, the dispute shall be further reviewed. The Director of DARPA may elect to conduct this review personally or through a designee or jointly with a senior executive (no lower than (INSERT A LEVEL OF EXECUTIVE FAR ENOUGH REMOVED FROM THE PROGRAM TO MAINTAIN A GREATER LEVEL OF IMPARTIALITY) level) appointed by the Contractor. Following the review, the Director of DARPA or designee will resolve the issue(s)and notify the Parties in writing. Such resolution is not subject to further administrative review and, to the extent permitted by law, shall be final and binding.

ARTICLE VII: PATENT RIGHTS

A. Definitions

1. "Invention" means any invention or discovery which is or may be patentable or otherwise protectable under Title 35 of the United States Code.

2. "Made" when used in relation to any invention means the conception or first actual reduction to practice of such invention.

3. "Practical application" means to manufacture, in the case of a composition of product; to practice, in the case of a process or method, or to operate, in the case of a machine or system; and, in each case, under such conditions as to establish that the invention is capable of being

utilized and that its benefits are, to the extent permitted by law or Government regulations, available to the public on reasonable terms.

4. "Subject invention" means any Contractor invention conceived or first actually reduced to practice in the performance of work under this Agreement.

5. "Interface specification" means non-proprietary, fully documented draft and final specification for the satellite-to-satellite mechanical and electrical interfaces developed for the Orbital Express Demonstration System, together with source code and full documentation for all enabling software, and specification of associated protocols (e.g., communications, satellite states and modes, etc.).

B. Allocation of Principal Rights

Unless the Contractor shall have notified DARPA (in accordance with subparagraph C.2 below) that the Contractor does not intend to retain title, the Contractor shall retain the entire right, title, and interest throughout the world to each subject invention consistent with the provisions of this Article, and 35 U.S.C. § 202. With respect to any subject invention in which the Contractor retains title, DARPA shall have a non-exclusive, nontransferable, irrevocable, paid-up license to practice or have practiced on behalf of the United States the subject invention throughout the world, except as stated in Paragraph K of this article.

C. Invention Disclosure, Election of Title, and Filing of Patent Application

1. The Contractor shall disclose each subject invention to DARPA within four (4) months after the inventor discloses it in writing to his company personnel responsible for patent matters. The disclosure to DARPA shall be in the form of a written report and shall identify the Agreement under which the invention was made and the identity of the inventor(s). It shall be sufficiently complete in technical detail to convey a clear understanding to the extent known at the time of the disclosure, of the nature, purpose, operation, and the physical, chemical, biological, or electrical characteristics of the invention. The disclosure shall also identify any publication, sale, or public use of the invention and whether a manuscript describing the invention has been submitted for publication and, if so, whether it has been accepted for publication at the time of disclosure. The Contractor shall also submit to DARPA an annual listing of subject inventions.

2. If the Contractor determines that it does not intend to retain title to any such invention, the Contractor shall notify DARPA, in writing, within eight (8) months of disclosure to DARPA. However, in any case where publication, sale, or public use has initiated the one (1)-year statutory period wherein valid patent protection can still be obtained in the United States, the period for such notice may be shortened by DARPA to a date that is no more than sixty (60) calendar days prior to the end of the statutory period.

3. The Contractor shall file its initial patent application on a subject invention to which it elects to retain title within one (1) year after election of title or, if earlier, prior to the end of the statutory period wherein valid patent protection can be obtained in the United States after a publication, or sale, or public use. The Contractor may elect to file patent applications in

additional countries (including the European Patent Office and the Patent Cooperation Treaty) within either ten (10) months of the corresponding initial patent application or six (6) months from the date permission is granted by the Commissioner of Patents and Trademarks to file foreign patent applications, where such filing has been prohibited by a Secrecy Order.

4. Requests for extension of the time for disclosure election, and filing under Article VII, paragraph C, may, at the discretion of DARPA, and after considering the position of the Contractor, be granted.

D. Conditions When the Government May Obtain Title

Upon DARPA's written request, the Contractor shall convey title to any subject invention to DARPA under any of the following conditions:

1. If the Contractor fails to disclose or elects not to retain title to the subject invention within the times specified in paragraph C of this Article; provided, that DARPA may only request title within sixty (60) calendar days after learning of the failure of the Contractor to disclose or elect within the specified times.

2. In those countries in which the Contractor fails to file patent applications within the times specified in paragraph C of this Article; provided, that if the Contractor has filed a patent application in a country after the times specified in paragraph C of this Article, but prior to its receipt of the written request by DARPA, the Contractor shall continue to retain title in that country; or

3. In any country in which the Contractor decides not to continue the prosecution of any application for, to pay the maintenance fees on, or defend in reexamination or opposition proceedings on, a patent on a subject invention.

E. Minimum Rights to the Contractor and Protection of the Contractor's Right to File

1. The Contractor shall retain a non-exclusive, royalty-free license throughout the world in each subject invention to which the Government obtains title, except if the Contractor fails to disclose the invention within the times specified in paragraph C of this Article. The Contractor license extends to the domestic (including Canada) subsidiaries and affiliates, if any, of the Contractor within the corporate structure of which the Contractor is a party and includes the right to grant licenses of the same scope to the extent that the Contractor was legally obligated to do so at the time the Agreement was awarded. The license is transferable only with the approval of DARPA, except when transferred to the successor of that part of the business to which the invention pertains. DARPA approval for license transfer shall not be unreasonably withheld.

2. The Contractor domestic license may be revoked or modified by DARPA to the extent necessary to achieve expeditious practical application of the subject invention pursuant to an application for an exclusive license submitted consistent with appropriate provisions at 37 CFR Part 404. This license shall not be revoked in that field of use or the geographical areas in which the Contractor has achieved practical application and continues to make the benefits of the

invention reasonably accessible to the public. The license in any foreign country may be revoked or modified at the discretion of DARPA to the extent the Contractor, its licensees, or the subsidiaries or affiliates have failed to achieve practical application in that foreign country.

3. Before revocation or modification of the license, DARPA shall furnish the Contractor a written notice of its intention to revoke or modify the license, and the Contractor shall be allowed thirty (30) calendar days (or such other time as may be authorized for good cause shown) after the notice to show cause why the license should not be revoked or modified.

F. Action to Protect the Government's Interest

1. The Contractor agrees to execute or to have executed and promptly deliver to DARPA all instruments necessary to (i) establish or confirm the rights the Government has throughout the world in those subject inventions to which the Contractor elects to retain title, and (ii) convey title to DARPA when requested under paragraph D of this Article and to enable the Government to obtain patent protection throughout the world in that subject invention.

2. The Contractor agrees to require, by written agreement, that employees of the Members of the Contractor, other than clerical and non-technical employees, agree to disclose promptly in writing, to personnel identified as responsible for the administration of patent matters and in a format acceptable to the Contractor, each subject invention made under this Agreement in order that the Contractor can comply with the disclosure provisions of paragraph C of this Article. The Contractor shall instruct employees, through employee agreements or other suitable educational programs, on the importance of reporting inventions in sufficient time to permit the filing of patent applications prior to U.S. or foreign statutory bars.

3. The Contractor shall notify DARPA of any decisions not to continue the prosecution of a patent application, pay maintenance fees, or defend in a reexamination or opposition proceedings on a patent, in any country, not less than thirty (30) calendar days before the expiration of the response period required by the relevant patent office.

4. The Contractor shall include, within the specification of any United States patent application and any patent issuing thereon covering a subject invention, the following statement: "This invention was made with Government support under Agreement No. **MDA972-00-9-XXXX** awarded by DARPA. The Government has certain rights in the invention."

G. Lower Tier Agreements

The Contractor shall include this Article, suitably modified, to identify the Parties, in all subcontracts or lower tier agreements, regardless of tier, for experimental, development, or research work.

H. Reporting on Utilization of Subject Inventions

The Contractor agrees to submit, during the term of the Agreement, an annual report on the utilization of a subject invention or on efforts at obtaining such utilization that are being made by the Contractor or its licensees or assignees. Such reports shall include information regarding the status of development, date of first commercial sale or use, gross royalties received by the subcontractor (s), and such other data and information as the agency may reasonably specify. The Contractor also agrees to provide additional reports as may be requested by DARPA in connection with any march-in proceedings undertaken by DARPA in accordance with paragraph J of this Article. Consistent with 35 U.S.C. § 202(c)(5), DARPA agrees it shall not disclose such information to persons outside the Government without permission of the Contractor.

I. Preference for American Industry

Notwithstanding any other provision of this clause, the Contractor agrees that it shall not grant to any person the exclusive right to use or sell any subject invention in the United States or Canada unless such person agrees that any product embodying the subject invention or produced through the use of the subject invention shall be manufactured substantially in the United States or Canada. However, in individual cases, the requirements for such an agreement may be waived by DARPA upon a showing by the Contractor that reasonable but unsuccessful efforts have been made to grant licenses on similar terms to potential licensees that would be likely to manufacture substantially in the United States or that, under the circumstances, domestic manufacture is not commercially feasible.

J. March-in Rights

The Contractor agrees that, with respect to any subject invention in which it has retained title, DARPA has the right to require the Contractor, an assignee, or exclusive licensee of a subject invention to grant a non-exclusive license to a responsible applicant or applicants, upon terms that are reasonable under the circumstances, and if the Contractor, assignee, or exclusive licensee refuses such a request, DARPA has the right to grant such a license itself if DARPA determines that:

1. Such action is necessary because the Contractor or assignee has not taken effective steps, consistent with the intent of this Agreement, to achieve practical application of the subject invention;

2. Such action is necessary to alleviate health or safety needs which are not reasonably satisfied by the Contractor, assignee, or their licensees;

3. Such action is necessary to meet requirements for public use and such requirements are not reasonably satisfied by the Contractor, assignee, or licensees; or

4. Such action is necessary because the agreement required by paragraph (I) of this Article has not been obtained or waived or because a licensee of the exclusive right to use or sell any subject invention in the United States is in breach of such Agreement.

K. Supplement to Paragraph B, Allocation of Principle Rights

Notwithstanding Paragraph B above, with respect to any subject invention relating to the Interface Specification, DARPA shall have a non-exclusive, transferable, irrevocable, paid-up license to use, duplicate, release, or disclose, the subject invention, in whole or in part, in any manner and for any purposes whatsoever, and to have or permit others to do so.

ARTICLE VIII: DATA RIGHTS

A. Definitions

1. "Government Purpose Rights", as used in this article, means rights to use, duplicate, or disclose Data, in whole or in part and in any manner, for Government purposes only, and to have or permit others to do so for Government purposes only.

2. "Unlimited Rights", as used in this article, means rights to use, duplicate, release, or disclose, Data in whole or in part, in any manner and for any purposes whatsoever, and to have or permit others to do so.

3. "Data", as used in this article, means recorded information, regardless of form or method of recording, which includes but is not limited to, technical data, software, trade secrets, and mask works. The term does not include financial, administrative, cost, pricing or management information and does not include subject inventions included under Article VII.

4. "Interface specification" means non-proprietary, fully documented preliminary and final specifications for the satellite-to-satellite mechanical and electrical interfaces developed for the Orbital Express Demonstration System, together with source code and full documentation for all enabling software, and specification of associated protocols (e.g., communications, satellite states and modes, etc.).

B. Allocation of Principal Rights

1. The Parties agree that in consideration for Government funding, the Contractor intends to reduce to practical application items, components and processes developed under this Agreement.

2. The Contractor agrees to retain and maintain in good condition until (INSERT NUMBER OF YEAR) ( ) years after completion or termination of this Agreement, all Data necessary to achieve practical application. In the event of exercise of the Government's March-in Rights as set forth under Article VII or subparagraph B.3 of this article, the Contractor agrees, upon written request from the Government, to deliver at no additional cost to the Government, all Data necessary to achieve practical application within sixty (60) calendar days from the date of the written request. The Government shall retain Unlimited Rights, as defined in paragraph A above, to this delivered Data.

3. The Contractor agrees that, with respect to Data necessary to achieve practical application, DARPA has the right to require the Contractor to deliver all such Data to DARPA in accordance with its reasonable directions if DARPA determines that:

(a) Such action is necessary because the Contractor or assignee has not taken effective steps, consistent with the intent of this Agreement, to achieve practical application of the technology developed during the performance of this Agreement;

(b) Such action is necessary to alleviate health or safety needs which are not reasonably satisfied by the Contractor, assignee, or their licensees; or

(c) Such action is necessary to meet requirements for public use and such requirements are not reasonably satisfied by the Contractor, assignee, or licensees.

4. With respect to Data developed, except for data related to the interface design, the Government shall receive Government Purpose Rights, as defined in paragraph A above. With respect to all Data developed, in the event of the Government's exercise of its right under subparagraph B.2 of this article, the Government shall receive Unlimited Rights.

5. With respect to Data related to the Interface Specification, the Government shall receive Unlimited Rights. The satellite-to-satellite interface preliminary and final specifications, enabling software and associated protocols, for the Orbital Express ATD program must be delivered to the Government free of restriction on their use or further distribution.

ARTICLE IX: FOREIGN ACCESS TO TECHNOLOGY

This Article shall remain in effect during the term of the Agreement and for (INSERT NUMBER OF YEARS) ( ) years thereafter.

A. Definition

1. "Foreign Firm or Institution" means a firm or institution organized or existing under the laws of a country other than the United States, its territories, or possessions. The term includes, for purposes of this Agreement, any agency or instrumentality of a foreign Government; and firms, institutions or business organizations which are owned or substantially controlled by foreign Governments, firms, institutions, or individuals.

2. "Know-How" means all information including, but not limited to discoveries, formulas, materials, inventions, processes, ideas, approaches, concepts, techniques, methods, software, programs, documentation, procedures, firmware, hardware, technical data, specifications, devices, apparatus and machines.

3. "Technology" means discoveries, innovations, Know-How and inventions, whether patentable or not, including computer software, recognized under U.S. law as

intellectual creations to which rights of ownership accrue, including, but not limited to, patents, trade secrets, maskworks, and copyrights developed under this Agreement.

B. General

The Parties agree that research findings and technology developments arising under this Agreement may constitute a significant enhancement to the national defense, and to the economic vitality of the United States. Accordingly, access to important technology developments under this Agreement by Foreign Firms or Institutions must be carefully controlled. The controls contemplated in this Article are in addition to, and are not intended to change or supersede, the provisions of the International Traffic in Arms Regulation (22 CFR pt. 121 et seq.), the DoD Industrial Security Regulation (DoD 5220.22-R) and the Department of Commerce Export Regulation (15 CFR pt. 770 et seq.)

C. Restrictions on Sale or Transfer of Technology to Foreign Firms or Institutions

1. In order to promote the national security interests of the United States and to effectuate the policies that underlie the regulations cited above, the procedures stated in subparagraphs C.2, C.3, and C.4 below shall apply to any transfer of Technology. For purposes of this paragraph, a transfer includes a sale of the company, and sales or licensing of Technology. Transfers do not include:

(a) sales of products or components, or

(b) licenses of software or documentation related to sales of products or components, or

(c) transfer to foreign subsidiaries of the Contractor for purposes related to this Agreement, or

(d) transfer which provides access to Technology to a Foreign Firm or Institution which is an approved source of supply or source for the conduct of research under this Agreement provided that such transfer shall be limited to that necessary to allow the firm or institution to perform its approved role under this Agreement.

2. The Contractor shall provide timely notice to DARPA of any proposed transfers from the Contractor of Technology developed under this Agreement to Foreign Firms or Institutions. If DARPA determines that the transfer may have adverse consequences to the national security interests of the United States, the Contractor, its vendors, and DARPA shall jointly endeavor to find alternatives to the proposed transfer which obviate or mitigate potential adverse consequences of the transfer but which provide substantially equivalent benefits to the Contractor.

3. In any event, the Contractor shall provide written notice to the DARPA Agreements Officer's Representative and Agreements Officer of any proposed transfer to a

foreign firm or institution at least sixty (60) calendar days prior to the proposed date of transfer. Such notice shall cite this Article and shall state specifically what is to be transferred and the general terms of the transfer. Within thirty (30) calendar days of receipt of the Contractor's written notification, the DARPA Agreements Officer shall advise the Contractor whether it consents to the proposed transfer. In cases where DARPA does not concur or sixty (60) calendar days after receipt and DARPA provides no decision, the Contractor may utilize the procedures under Article VI, Disputes. No transfer shall take place until a decision is rendered.

4. In the event a transfer of Technology to Foreign Firms or Institutions which is NOT approved by DARPA takes place, the Contractor shall (a) refund to DARPA funds paid for the development of the Technology and (b) the Government shall have a non-exclusive, nontransferable, irrevocable, paid-up license to practice or have practiced on behalf of the United States the Technology throughout the world for Government and any and all other purposes, particularly to effectuate the intent of this Agreement. Upon request of the Government the Contractor shall provide written confirmation of such licenses.

D. Lower Tier Agreements

the Contractor shall include this Article, suitably modified, to identify the Parties, in all subcontracts or lower tier agreements, regardless of tier, for experimental, developmental, or research work.

ARTICLE X: CIVIL RIGHTS ACT

This Agreement is subject to the requirements of Title VI of the Civil Rights Act of 1964 as amended (42 U.S.C. 2000-d) relating to nondiscrimination in employment.

ARTICLE XI: INSURANCE

Contractor shall maintain a) Workers' compensation and employer's liability, (b) General liability; and (c) Automobile liability with the minimum amounts of liability indicated, or commercial equivalent as listed in FAR 28.307-2(a), (b), and (c).

ARTICLE XII: GOVERNMENT FURNISHED EQUIPMENT, PROPERTY, INFORMATION, FACILITIES, AND SERVICES

The following Government Equipment property, information facilities, and services shall be provided upon the written approval of the cognizant contracting officers:

(Offeror will list all desired GFE, GFP, GFI, GFF, and GFS.)

ARTICLE XIII: SECURITY

This program shall be provided protection as required by the appropriate security requirements required by the DD Form 254 (Attachment 3; to be provided by DARPA). The highest level of classification involved in the performance of this Agreement is Top Secret/SCI. It is the Government's position that the highest security classification of any item deliverable as a result of this Agreement is Top Secret/Sensitive Compartmented Information (SCI). In order to ensure that critical team analyses and trade studies conducted early in Phase I fully consider U.S. national security space missions -- as well as civil and commercial space activities -- team leads must be capable of obtaining access to U.S. Government Top Secret/Sensitive Compartmented Information (SCI). This agreement is unclassified.

ARTICLE XIV: SUBCONTRACTORS

The Contractor is authorized to use best commercial practices under this Agreement. This authorization includes, but is not limited to, waiver from competitive bidding where appropriate and the relief from normal flow-down requirements to subcontractors where it impacts the Orbital Express Advanced Technology Demonstration (ATD) Program.

ARTICLE XV: ORDER OF PRECEDENCE

In the event of any inconsistency within this Agreement the inconsistency shall be resolved by giving precedence in the following order: (1) The Agreement, (2) Attachments to the Agreement.

ARTICLE XVI: EXECUTION

This Agreement constitutes the entire agreement of the Parties and supersedes all prior and contemporaneous agreements, understandings, negotiations and discussions among the Parties, whether oral or written, with respect to the subject matter hereof. This Agreement may be revised only by written consent of the Contractor and the DARPA Agreements Officer. This Agreement, or modifications thereto, may be executed in counterparts each of which shall be deemed as original, but all of which taken together shall constitute one and the same instrument.

AGREEMENT NUMBER: MDA972-00-9-XXXX
ATTACHMENT NUMBER 1

Task Description Document (TDD)

[To be submitted in contractor format]

REPORT REQUIREMENTS

A. QUARTERLY REPORT

On or before ninety (90) calendar days after the effective date of the Agreement and quarterly thereafter throughout the term of the Agreement, the Contractor shall submit or otherwise provide a quarterly business report. Two (2) copies shall be submitted or otherwise provided to the DARPA Program Manager, one (1) copy shall be submitted or otherwise provided to the DARPA Agreements Officer and one (1) copy shall be submitted or otherwise provided to DARPA/TTO, Attn: Assistant Director for Program Management.

This report shall provide summarized details of the resource status of this Agreement, including the status of the Contractor contributions, if any. This report will include a quarterly accounting of current expenditures.

B. PAYABLE MILESTONES REPORTS

The Contractor shall submit or otherwise provide to the DARPA Agreements Officer's Representative, documentation describing the extent of accomplishment of Payable Milestones. This information shall be as required by Article V, paragraph B and shall be sufficient for the DARPA Agreements Officer's Representative to reasonably verify the accomplishment of the milestone in accordance with the Task Description Document (TDD).

C. FINAL REPORT (NOTE: The Final Report is the last Payable Milestone for the completed Agreement)

1. The Contractor shall submit or otherwise provide a Final Report making full disclosure of all major developments by the Contractor upon completion of the Agreement or within sixty (60) calendar days of termination of this Agreement. With the approval of the DARPA Agreements Officer's Representative, reprints of published articles may be attached to the Final Report. Two (2) copies shall be submitted or otherwise provided to the DARPA Agreements Officer's Representative and one (1) copy shall be submitted or otherwise provided to DARPA/TTO, Attn: Assistant Director for Program Management. One (1) copy shall be submitted to the Defense Technical Information Center, Attn: DTIC-BCS, 8725 John J. Kingman Road, Suite 0944, Fort Belvoir, VA 22060-0944.

2. The Final Report shall be marked with a distribution statement to denote the extent of its availability for distribution, release, and disclosure without additional approvals or authorizations. The Final Report shall be marked on the front page in a conspicuous place with the following marking:

"<u>DISTRIBUTION STATEMENT B.</u> Distribution authorized to U.S. Government agencies only to protect information not owned by the U.S. Government and protected by a contractor's "limited rights" statement, or received with the understanding that it not be routinely transmitted outside the U.S. Government. Other requests for this document shall be referred to DARPA/Technical Information Officer."

AGREEMENT NUMBER: MDA972-00-9-XXXX
ATTACHMENT NUMBER 3

Contract Security Classification Specification (DD 254)

[To be completed at time of award]

AGREEMENT NUMBER: MDA972-00-9-XXXX
ATTACHMENT NUMBER 4

SCHEDULE OF PAYMENTS AND ACCOMPLISHMENT CRITERIA AND DELIVERABLES (NOTIONAL)

A. Payment Schedule

The Contractor shall perform the work required by Attachment I. The Contractor shall be paid for each Payable Milestone accomplished in accordance with the Schedule of Payments and Payable Milestones set forth below.

B. Schedule of Payments and Payable Milestones

Phase I:		Payment	Milestone
MS	Payable Milestones	Payment	Schedule
1	Utility/Rqts Analysis, Prelim LCC/Cost Effect Analysis, Baseline Msn Nomination	$	3 months after award

<table>
<tr><th>Phase I:</th><th></th><th>Payment</th><th>Milestone</th></tr>
<tr><td>MS</td><td>Payable Milestones</td><td>Payment</td><td>Schedule</td></tr>
<tr><td colspan="4">

Deliverables:

Satellite failure mode analysis and systems / components obsolescence analysis
OEOS mission utility / requirements analysis
Refined Operational System Concept (OSC)
Preliminary OEOS cost effectiveness, methodology, trade studies and analysis
Preliminary OEOS life-cycle cost, methodology, trade studies and analysis
Preliminary ATD Risk Assessment / Risk Mitigation Plan
Preliminary ATD Technology Development Plan
Baseline (“Design-To”) servicing mission nomination and trade studies

Accomplishments - Information presented demonstrates:

Expertise in space system engineering and design
Thorough understanding of space system failure modes and obsolescence
Thorough knowledge of space missions and CONOPS
Sound Operational System Concept
VV&A of space system performance and space mission models
Thorough understanding of key life-cycle cost, cost-effectiveness and operational effectiveness issues and trades
VV&A of cost models
Credible life-cycle cost and cost effectiveness results
Understanding of key enabling technologies and their maturity

</td></tr>
<tr><td>2</td><td>Interfaces Joint Initial Design Review (IDR)</td><td>$</td><td>6 months after award</td></tr>
<tr><td colspan="4">

Deliverables:

Satellite servicing interfaces joint Initial Design Review (IDR)

Accomplishments - Information presented demonstrates:

Mechanical and electrical interfaces Specification (together with source code and full documentation for all enabling software, and specification of associated protocols (e.g., communications, satellite states and modes, etc.) consistent with the interface guidance provided at the System Requirements Review (SRR)
</td></tr>
<tr><td>3</td><td>OEOS/OEDS IDR, Prelim CONOPS, Final LCC/Cost Effect Analysis, Prelim Demo Concept</td><td>$</td><td>6 months after award</td></tr>
</table>

Phase I:		Payment	Milestone
MS	Payable Milestones	Payment	Schedule

	• Deliverables:
	  ◦ OSOS Initial Design Review (IDR)
	  ◦ OEDS IDR
	  ◦ Preliminary satellite servicing CONOPS and supporting trade studies
	  ◦ Final OEOS cost effectiveness, methodology, trade studies and analysis
	  ◦ Final OEOS life-cycle cost, methodology, trade studies and analysis
	  ◦ Final OEOS affordability analysis supporting a DARPA decision on a target price for the Operational System
	  ◦ Preliminary on-orbit Demonstration Concept
	  ◦ Preliminary demonstration Detailed Test Plan
	  ◦ Revised ATD Risk Assessment / Risk Mitigation Plan
	  ◦ Revised ATD Technology Development Plan
	• Accomplishments - Information presented demonstrates:
	  ◦ Legacy between OEOS and OEDS designs
	  ◦ Thorough understanding of OEOS and OEDS design trades
	  ◦ Sound OEOS CONOPS
	  ◦ Life-cycle cost and cost effectiveness results of suitable rigor and form for presentation to DoD decision makers
	  ◦ Sound demonstration concept and preliminary test plan
	  ◦ Refined understanding of key enabling technologies and their maturity
	  ◦ Progressive development of key enabling technologies		

<table>
<tr><th>Phase I:</th><th></th><th>Payment</th><th>Milestone</th></tr>
<tr><td>MS</td><td>Payable Milestones</td><td>Payment</td><td>Schedule</td></tr>
<tr><td>4</td><td>OEOS FDR, OEDS IPR, Final OSC/CONOPS, Final Demo Concept</td><td>$</td><td>9 months after award</td></tr>
<tr><td colspan="4">

Deliverables:

OEOS Final Design Review (FDR)
OEDS design In-Process Review (IPR)
Final Operational System Concept
Final satellite servicing CONOPS and supporting trade studies
Final on-orbit Demonstration Concept
Revised demonstration Detailed Test Plan
Final ATD Risk Assessment / Risk Mitigation Plan
Final ATD Technology Development Plan
Preliminary Orbital Express Transition Plan

Accomplishments - Information presented demonstrates:

Level of OEOS design detail is sufficient to validate all aspects of OEDS design
Progress toward reducing the risk of key enabling technologies
Refinement of OEDS design
Thorough understanding of key features of OEDS demonstration concept
Refinement of Detailed test Plan
Progressive development of key enabling technologies
Understanding of key features of ATD Transition Plan

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<table>
<tr><th>Phase I:</th><th></th><th>Payment</th><th>Milestone</th></tr>
<tr><td>MS</td><td>Payable Milestones</td><td>Payment</td><td>Schedule</td></tr>
<tr><td>5</td><td>OEDS PDR, Final Detailed Test Plan, Final RAMP, Final Tech Development Plan</td><td>$</td><td>12 months after award</td></tr>
<tr><td colspan="4">

Deliverables:

OEDS PDR
Final demonstration Detailed Test Plan
Final ATD Risk Assessment / Risk Mitigation Plan
Final ATD Technology Development Plan
Revised Orbital Express Transition Plan

Accomplishments - Information presented demonstrates:

OEDS preliminary design
OEDS preliminary design with direct legacy to final OEOS design, and validates key features of the OEOS
Preliminary, Non-proprietary, fully documented mechanical and electrical satellite servicing interface specification, together with source code and full documentation for all enabling software, and specification of associated protocols (e.g., communications, satellite states and modes, etc.)
Progressive development of key enabling technologies
Refinement of the ATD Transition Plan

</td></tr>
<tr><td>6</td><td>Final Report</td><td>$</td><td>14 months after award</td></tr>
<tr><td colspan="4">

Deliverables:

Final Phase I report

Accomplishments- Information presented demonstrates:

Summation of Phase I activities and accomplishments

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</table>

AGREEMENT NUMBER: MDA972-00-9-XXXX
ATTACHMENT NUMBER 5

LIST OF GOVERNMENT AND ABC REPRESENTATIVES

GOVERNMENT:

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7.0 DARPA Agreements Authority and Section 845 of the 1994 National Defense Authorization Act

DARPA "Agreements authority" was enacted as section 251, Public Law 101-189, the FY 1990 National Defense Authorization Act (codified at 10 U.S.C. § 2371) and is currently found in part of 10 U.S.C. § 2371. Section 845 of the 1994 National Defense Authorizations Act allows DARPA, on a pilot basis to use non-procurement Agreements for purely military Research and Development and, prototype projects and technology demonstrations of hardware directly relevant to weapon systems.

The primary benefit of this authority is that DARPA can tailor the contracting process to each project rather than conforming to predetermined contracting rules. This authority should increase the efficiency of DARPA's limited resources. DARPA also hopes use of this authority will shorten development time for these projects and enhance affordability.

This Section 845 Authority allows DARPA to:

1) Use Agreements even if a procurement contract would be appropriate or feasible.
2) Execute projects with or without cost sharing.
3) Implement streamlined acquisition procedures (e.g., using Generally Accepted Accounting Practices in lieu of Government Cost Accounting Standards).
4) Focus on goals and objectives rather than acquisition regulations.

Commercial Agreement Participants benefit from:

1) Increased Government flexibility in structuring these Agreements (e.g., flexibility on patent and intellectual property issues).
2) Being able to use commercial rather than Government procedures for doing business.
3) Government funding with minimum Government bureaucracy.

Both Groups Benefit in that:

1) Armed Services Procurement Act, CICA, FAR, DFARS, and all procurement system regulations are inapplicable.
2) Existing regulations, MILSPECS, directives may but need not be applied.

System Capability Document

Orbital Express System This document describes the design and capabilities for the Orbital Express Operations System (OEOS). The OEOS is a system where satellites designed and equipped with an Orbital Express-derived standard mechanical and electrical interface are enabled for the automated receipt of fluid consumables (fuel and cryogens) and upgraded electronic components via an unmanned servicing spacecraft (a so-called “Autonomous Space Transfer and Robotic Orbiter” vehicle, or ASTRO). In addition, the ASTRO will have the ability to host microsatellites. To capitalize on the availability of the ASTRO servicing spacecraft and affordable replenishment and upgrade commodities, satellites of the future (or "NEXTSats") will be designed to enable routine, automated on-orbit servicing. NEXTSats must be designed such that fluid transfer interfaces and ORU installation ports be unobstructed and readily accessible by ASTRO.

The Orbital Express SCD is not intended to specify the design, but to provide government insight on the basic bounds of the solution space. The intent of the SCD is to provide guidance on WHAT Orbital Express should be, not How to achieve those objectives. There is no list of advanced technologies that must be included in your Orbital Express design. The offeror is encouraged to fully exploit innovative concepts and advanced technologies for radically reducing design, fabrication, test, launch and on-orbit operations of the Orbital Express Program. The government envisions that the technologies and operations concepts proven in this demonstration program will result in major changes in the design and operations of future space systems.

The capabilities in this appendix shall serve as bounds for the Orbital Express Program and are tradable except for the following:

- Unmanned, Autonomous Guidance, Navigation and Control Operation (Auto GN&C)
- Non-proprietary Interface
- Transfer of Orbital Replacement Units (ORU)
- Transfer of fluids

The OEOS will be judged on its documented potential to effectively and affordably perform the design mission as well as its future design potential. Only through a thorough exploration of the trade space can the offeror define an OEOS that will form the basis of a future architecture that provides the most potential for satellite servicing.

The offeror’s Orbital Express Demonstration System (OEDS) design will focus on the demonstration launch and maturing of the critical technologies fundamental to the operational implementation of the Orbital Express concept. The government acknowledges that the OEDS will not demonstrate all aspects and functions of the Satellite Servicing concept. We believe focusing on a simple docking and servicing mission will allow the Orbital Express Program to answer some of the fundamental technical questions for a future satellite servicing system. Proper balancing the trade-off between mission specific and generic satellite servicing technologies will be critical to the success of the OEOS.

This document follows the format of the Work Outline, where applicable, in Section 4.0 and provides a minimum framework for describing the offeror's Operational Concept. In many instances specific sub-levels do not contain a description of a desired system capability but are defined as a placeholder for the Operation Concept. The offeror is free to propose a completely different work outline. However, to allow for an equitable comparison of competing concepts, the offeror shall ensure their work outline addresses all of the program elements in this document.

1.0 On-Orbit Servicing Utility

1.1 Operational System Concept The Orbital Express vision is to set the stage for the establishment of a routine, cost-effective, automated capability for re-supply and reconfiguration of on-orbit spacecraft. We envision routine, automated satellite servicing will provide spacecraft with unprecedented freedom of maneuver, allowing satellite coverage to be adjusted, or optimized, at will, or enable spacecraft to employ unpredictable maneuvers to counter possible threats or adversary activity scheduling. We also anticipate that routine, automated, preplanned upgrades or reconfiguration of spacecraft components will result in substantial reductions in space system acquisition and launch costs by significantly extending satellite on-orbit mission lifetimes, increasing mission flexibility and permitting reductions in spacecraft launch volume and mass.

The vision of post-2010 space operations foresees satellites designed and equipped with Orbital Express-derived standardized mechanical and electrical interfaces enabling automated receipt of fluid consumables (fuel and cryogens) and upgraded electronic components via an unmanned servicing spacecraft or ASTRO. Multiple ASTRO servicing spacecraft will remain permanently on-orbit, with each assigned to service satellites or host Microsatellites within a specified range of orbital inclinations and altitudes. Bulk fluids, electronic component upgrade units (ORUs) and Microsatellites will be regularly launched into orbit using relatively inexpensive space launch vehicles. These replenishment / upgrade payloads will serve as on-orbit "Commodities Spacecraft." ASTRO servicing spacecraft will autonomously rendezvous and dock with these Commodities Spacecraft, and will onload replenishment fluids or orbital replacement unit (ORU) components/systems destined for a specified objective satellite or Microsatellites for hosting. The ASTRO spacecraft will then autonomously transit between the on-orbit Commodities Spacecraft and the objective satellite (effecting any required orbital plane or altitude changes). The ASTRO will then accomplish autonomous rendezvous and docking, perform preplanned robotic fluid transfer or ORU installation, autonomously undock and separate from the serviced satellite, and then transit to a designated on-orbit location to begin the servicing cycle for another satellite.

The success of the Orbital Express program in realizing this vision of routine, unmanned, on-orbit satellite servicing will stimulate a revolution both in space system acquisition and in the flexibility with which space systems are employed. By enabling the adoption of an aircraft-like preplanned product improvement design philosophy, the cost of acquiring and operating satellite systems will be drastically reduced. Enabling routine consumable replenishment for the first time, space systems will be conferred with unprecedented mobility. This will permit smaller numbers of satellites to accomplish critical national security missions, or infuse sufficient resiliency and adaptability in commercial constellations that the loss of service that would otherwise result from a catastrophic on-orbit satellite failure can be rapidly and affordably mitigated or service fully restored.

1.2 CONOPS The government expects the contractor to perform the required trade studies, analyses, modeling and simulations to fully define the CONOPS. At a minimum these trades shall include but are not limited to:

The launch of replenishment spacecraft (Commodities Spacecraft), including the proximity to the servicing spacecraft and Next spacecraft.

The launching of spacecraft “Light”, without a full load of fuel, to save on spacecraft structure and reduce launch costs.

Methods of orbit change for rendezvous.

The level of autonomy of the ASTRO and NEXTSats and the level of cooperation by the NEXTSat.

Details for the final approach and docking of the ASTRO and methods of controlling the combined satellite system.

Possible uses for the Microsatellites that can be hosted by ASTRO or a NEXTSat.

Methods to control contamination and contain debris generated on orbit as well as disposition of all components at the end of their useful life.

2.0 Life-Cycle Cost and Cost Effectiveness Analysis

2.1 Life-Cycle Cost and Cost Effectiveness The contractor shall perform the trades, analyses, and modeling and simulation necessary to define the cost effectiveness and life-cycle cost associated with routine, automated re-supply and reconfiguration of on-orbit spacecraft. Life cycle cost analyses shall consider a 20 year life cycle in light of historical experience with satellite failure modes and rates of obsolescence for systems / components. The analyses shall include the cost of development, acquisition, ownership, and disposal. Particular attention will be paid to a through and accurate estimate of all the support costs associated with the contractor's preferred CONOPS. All life cycle cost analyses shall clearly demonstrate the cost sensitivity to variations in key parameters and assumptions. At a minimum, trades should be conducted in terms of:

"Repair vs. Replace" satellite capability recovery strategies
Higher risk tolerance for launch failure for replenishment payloads
Launch cost impact of frequent launches of lower-value, lower volume, lower mass replenishment payloads
Required enabling launch cost for replenishment payloads

3.0 Servicing Vehicle

3.1 Spacecraft Bus The spacecraft structure is not limited to any existing or current spacecraft bus design. Advanced design methodologies that enable low cost manufacturing technologies should be explored. The two primary system drivers are mission effectiveness and affordability.

3.1.1 Design The bus design must be capable of meeting all of the mission requirements as defined in the CONOPS.

3.1.2 Size The Spacecraft bus must be large enough to support the Auto-GN&C System Servicer Interface, the Propulsion System, the Power System and the Vehicle Control System. The Bus must also support the electronic components upgrade system and the tankage for on-orbit refueling.

3.2 Auto-GN&C System ASTRO servicing spacecraft will autonomously rendezvous and dock with the on-orbit Commodities Spacecraft, and will onload replenishment fluids and/or orbital replacement unit (ORU) components/systems destined for a specified objective satellite. The ASTRO spacecraft will then autonomously transit between the on-orbit Commodities Spacecraft and the NEXTSat (effecting any required orbital plane or altitude changes), accomplish autonomous rendezvous and docking, perform preplanned robotic fluid transfer and/or ORU installation, autonomously undock and separate from the serviced satellite, and then transit to a designated on-orbit location to repeat the servicing cycle for another satellite.

3.3 Command, Data Handling and Processing System The on-board Vehicle Control System (VCS) must be compatible with the offeror's CONOPS. It is desired that the VCS architecture is modular to the point that systems can be tested, replaced and/or changed without impact on the system outside of the module replaced. It is desired that the VCS coordinate the activities of all avionics sub-systems and provide appropriate interfaces to the Servicer Interface and Receiver Satellite when docked. The VCS shall allow both autonomous control of the vehicle systems and interaction with the mission management system.

3.3.1 Flight Control This function performs the actual mechanical operation of the spacecraft to accomplish the mission and should be highly automated. The function continually monitors the present location and orientation and operates the thrusters and control systems to match the locations designated in the mission plan.

3.3.2 Navigation The navigation system shall provide accurate navigation throughout the mission and be capable of dynamically responding to course changes during all phases of the mission. The system shall be able to receive data from outside sources, such as Star trackers, optical sensors, GPS, etc and update the current S/C position based on that data.

3.3.3 System Status The VCS shall incorporated a system status architecture that allows autonomous on-board analysis, top-level mission control station monitoring and in-depth mission control station analysis.

3.4 Servicing Mission Instruction Set It is anticipated that the ground control facilities of both the ASTRO and the NEXTSat will closely collaborate in accomplishing satellite service mission planning. A resulting mission-specific instruction set will be uploaded to the ASTRO and the NEXTSat prior to mission execution. Planning a satellite servicing mission will include consideration of such factors as: the type and amount of fuel to be onloaded by the ASTRO for transfer to the NEXTSat; the type and number of electronic upgrade packages to be onloaded and transferred; ephemeris data for the ASTRO and the NEXTSat; mission timeline; guidance laws to be used; objective satellite mode during servicing; whether the NEXTSat is cooperative or non-cooperative; the unique configuration and status (and associated supporting spacecraft data) of the NEXTSat forecast for the planned time of servicing; and, whether the NEXTSat or the ASTRO will exercise control of the "joint spacecraft" after docking (considering the control authority of the objective satellite, the relative mass of ASTRO versus the NEXTSat, and the resulting combined center of mass of the docked spacecraft). The ASTRO will function with autonomy, controlling the execution of servicing tasks. Communications shall be seamless, with data passed through a variety of ground-to-space, space-to-space and space-to-ground paths.

3.5 Servicing Modes and States The Satellite Servicing Vehicle shall have all modes and states required to support the satellite servicing CONOPS and scenarios. These modes and states include a sleep mode (for when the ASTRO is awaiting a servicing mission), a microsatellite hosting mode, a logistics stocking mode(s) for on-loading fluids and electronics upgrade packages from the Commodities Spacecraft, orbital transfer mode(s), rendezvous and relative navigation modes, docking modes, fluid transfer modes, electronics upgrade transfer modes, docked satellite modes, undocking modes, pause modes, and safe modes.

3.6 Sensor System The Satellite Servicing Vehicle shall have all required sensors to allow navigation during all on-orbit operations. This includes station keeping, orbit transfer and rendezvous and final approach and docking with the NEXTSat or microsatellite.

3.7 Power and Power Distribution System The Satellite Servicing Vehicle shall have sufficient power generating capacity and storage to perform the mission defined in the OEOS mission design. This mission may have extended periods of time where there is little or no solar illumination due to orientation requirements or pointing requirements of the NEXTSat

3.8 Propulsion System The propulsion system shall be designed to provide overall system performance consistent with the OEOS mission design performance goals. In addition, the propulsion system shall be designed consistent with multiple missions, upgradability and multi-year life. Propulsion components may not need to be man-rated.

3.8.1 Main Engine The major thrust component must be able to make the required Delta V maneuvers to allow rendezvous with the NEXTSat. These maneuvers may include changes to orbit altitude, shape and inclination.

3.8.2 Maneuvering Thrusters Thrusters must be adequate in size and control to make the final adjustment to the ASTRO to allow close maneuvering and docking with the NEXTSat without making un-necessary contact or plume impingement.

3.9 Tracking, Telemetry and Communications System All communications should be robust and as reliable as possible. The Offeror’s communication architecture shall address all necessary changes to existing communication ground infrastructure. Data rates that allow adequate download of on-orbit telemetry for real-time monitoring of the mission are required. Receive capability sufficient to allow remote operation of the Servicer from the ground, for contingency operations is also required.

3.10 Fluid Payload Storage and Handling The Satellite Servicing Vehicle shall support the standard Orbital Express Interface. Provisions for plumbing to and from the fluid transfer interface to on-board tankage shall be provided. On-board tankage size to support the quantity of fuel transfer required by the CONOPS shall be provided, along with any baffles, etc. required to prevent fluid slosh and attitude control problems. Interface with the Satellite Servicing Vehicle on-board systems including communication, power and data shall be made available to the interface.

3.11 Hardware Payload Storage and Handling The Satellite Servicing Vehicle shall contain sufficient accommodations for the transfer to, containment and transport of, and subsequent transfer to a NEXTSat, of Orbital Replacement Units (ORU) and/or microsatellites as specified in the CONOPS. Disposition/Disposal of removed ORUs may be required, based upon the OEOS CONOPS.

3.12 Longevity / Durability The Satellite Servicing Vehicle shall be designed for a mission lifetime determined by trade study as providing the highest economic return for satellite refueling and electronics upgrade.

3.13 Environmental Survivability The Satellite Servicing Vehicle shall be designed for the space environments existing in the orbits of the serviced satellites and the Commodities Spacecraft, and for those regions of space traversed by the Satellite Servicing Vehicle during orbit transfer. These orbits and regions of space will be determined as a result of the economic trade studies done of satellite refueling and on-orbit electronics upgrade.

3.14 Integration and Test Integration and test of the Satellite Servicing Vehicle shall follow best commercial practice.

3.15 Disposition / Disposal The Satellite Servicing Vehicle shall be designed for end of life disposal in a manner which minimizes the creation of orbital debris. Preference shall be for disposal methods based on de-orbiting the Satellite Servicing Vehicle.

4.0 Satellite Servicing Interface The interface must be capable of supporting all functions established in the OEOS. This must include the ability to dock the Servicer and NEXTSat to allow the interfacing with the other Vehicle Control System (VCS), installing or changing of ORUs, transferring of fluids (fuels or cryogens) and hosting microsatellites. This interface must be sufficiently robust to react all loads between the two spacecraft with no damage to the interface or either spacecraft, including loads from docking and from joined on-orbit maneuvers

4.1 Mechanical Interfaces The Satellite Servicing Interface shall contain all necessary provisions for docking and mating of the Satellite Servicing Vehicle and NEXTSats or microsatellites. Any guide and locking devices required for docking per the CONOPS shall be provided.

4.2 Electrical Interfaces The electrical interface shall allow access to all required Satellite systems as defined in the CONOPS. This may include but is not limited to power, communications, on-orbit telemetry, guidance and command and control.

4.3 Tools / End Effectors The Satellite Interface shall contain the tools/end effectors required to perform the installation/replacement of the ORUs as defined in the CONOPS.

4.4 Longevity / Durability The interface shall be designed and built to withstand nominal usage based on the CONOPS for the life of the ASTRO. The interface on the NEXTSat shall have a design life based on the expected nominal usage of the interface for the life of the useful mission time.

5.0 NEXTSat Architecture

5.1 Spacecraft Bus The spacecraft structure is not limited to any existing or current spacecraft bus design. The goal is for all future satellites with upgrade capability and/or that are refuelable for extended life, to be configured as NEXTSats. Adequate structural support to position and to react identified loads from the interface shall be provided by the NEXTSat.

5.1.1 Design The bus design must be capable of meeting all of its primary mission requirements as well as the requirements to support the Standard Satellite-to-Satellite interface.

5.2 Command, Data Handling and Processing System The on-board Vehicle Control System (VCS) must be compatible with the offeror's CONOPS. It is desired that the VCS architecture is modular to the point that systems can be tested, replaced and/or changed without impact on the system outside of the module replaced. It is desired that the VCS coordinate the activities of all avionics sub-systems and provide appropriate interfaces to the Servicer Interface and Receiver Satellite when docked. The VCS shall allow both autonomous control of the vehicle systems and interaction with the mission management system as defined in the CONOPS.

5.2.1 Flight Control This function performs the actual mechanical operation of the spacecraft to accomplish the mission and should be highly automated. The functions continually monitor the present location and orientation and operate the thrusters and control systems to match the locations designated in the mission plan.

5.2.2 Navigation The navigation system shall provide accurate navigation throughout the mission and be capable of dynamically responding to course changes during all phases of the mission. The system shall be able to receive data from outside sources, such as Star trackers, optical sensors, GPS, etc and update the current S/C position based on that data.

5.2.3 System Status The VCS shall incorporated a system status architecture that allows autonomous on-board analysis, top-level mission control station monitoring and in-depth mission control station analysis.

5.3 Cooperative Servicing Aids System The NEXTSat shall have all required sensors to allow navigation during all on-orbit operations. This includes station keeping, orbit transfer, rendezvous, and final approach and docking with the ASTRO. As the majority of the final maneuvering for docking is performed by the ASTRO, the Sensors on the NEXTSat may be a subset of those on the ASTRO.

5.4 Servicing Modes and States The NEXTSat architecture shall provide for all modes and states required to support the satellite servicing CONOPS and scenarios. These modes and states include normal modes (for when the NEXTSat is performing its normal operations), orbital transfer mode(s) and guidance mode(s) if required by the CONOPS, rendezvous and relative navigation modes if required by the CONOPS, docking modes, fluid transfer modes, electronics upgrade transfer modes, docked satellite modes, undocking modes, pause modes, and safe modes.

5.5 Fluid Consumables Receipt and Handling The NEXTSat shall support the standard Orbital Express Interface. Provisions for plumbing to and from the fluid transfer interface to on-board tankage shall be provided. Interface with the NEXTSat on-board systems including communication, power and data shall be made available to the interface.

5.6 Hardware Receipt The NEXTSat shall support the standard Orbital Express Interface. Provisions for removal and receipt of standard upgrade electronics modules shall be provided.

5.7 Power and Power Distribution System The NEXTSat shall have sufficient power generating capacity and storage to perform the mission defined in the OEOS. This mission may have extended periods of time where there is little or no solar illumination due to pointing requirements of the ASTRO.

5.8 Propulsion System The propulsion system shall be designed to provide overall system performance consistent with the mission performance goals. In addition, the propulsion system shall be designed consistent with multiple missions, upgradability and multi-year life. Propulsion components do not need to be man-rated.

5.8.1 Main Engine The major thrust component must be able to make the required Delta V maneuvers for initial orbit insertion and, if called for by the OEOS mission design, to allow rendezvous with the ASTRO, if required. The majority of these operations will be performed by the ASTRO, but the ability to make small maneuvers that may include orbit altitude; shape and inclination may be required by the OEOS.

5.8.2 Maneuvering Thrusters Thrusters must be adequate in size and control to make any final adjustment to the NEXTSat called for by the OEOS mission design, and to allow close maneuvering and docking of the ASTRO without making un-necessary contact or plume impingement.

5.8.3 Attitude Control and Station Keeping The control system onboard the spacecraft must be able to maintain the spacecraft in a preplanned orientation for spacecraft health and communication with minimal use of reserves and intervention during down times. In addition, the control system must be capable of performing attitude control for inspection and docking upon approach by the servicer.

5.9 Tracking, Telemetry and Communications All communications systems should be robust and as reliable as possible. The Offeror's communication architecture shall address all necessary changes to existing communication ground infrastructure. Data rates that allow adequate download of on-orbit telemetry for real-time monitoring of the mission are required. Receive capability to allow remote operation of the NEXTSat from the ground is also required.

5.10 System Environmental Survivability The NEXTSat shall be designed for the space environments existing in the regions of space the NEXTSat will occupy. These orbits and regions of space will be determined as a result of the economic trade studies done of satellite refueling and on-orbit electronics upgrade.

5.11 Integration and Test Integration and test of the NEXTSat shall follow best commercial practice.

5.12 Longevity / Durability The NEXTSat shall be designed for a mission lifetime determined by trade study as providing the highest economic return for satellite refueling and electronics upgrade.

5.13 Disposition / Disposal The Contractor shall provide their concept for Disposition/ Disposal of the NEXTSat at the end of its useful life.

6.0 Commodities Spacecraft

6.1 Spacecraft Bus The spacecraft structure is not limited to any existing or current spacecraft bus design. Advanced design methodologies that enable low cost manufacturing technologies should be explored. The two primary system drivers are mission effectiveness and affordability.

6.1.1 Design The bus design must be capable of meeting all of the mission requirements as defined in the CONOPS.

6.1.2 Size The Spacecraft bus must be large enough to support the Servicer Interface, the propulsion system, the power system and the Vehicle Control System. The bus must also support the ORU storage system and the tankage for on-orbit fuel storage as defined in the CONOPS.

6.2 Command, Data Handling and Processing System The Commodities Spacecraft will autonomously maintain its position to allow rendezvous and docking, perform preplanned robotic fluid transfer, ORU transfer, autonomous undocking and separation of the ASTRO, as required by the CONOPs.

6.3 Cooperative Servicing Aids System The Commodities Spacecraft shall contain systems to aid in the rendezvous and docking of the ASTRO.

6.4 Load Transfer Modes and States The Commodities Spacecraft shall have all modes and states required to support the satellite servicing CONOPS and scenarios. These modes and states include a sleep mode (for when the Commodities Spacecraft is awaiting a servicing mission), rendezvous and relative navigation modes, docking modes, fluid transfer modes, electronics upgrade transfer modes, docked satellite modes, undocking modes, pause modes, and safe modes.

6.5 Fluid Consumables Payload Storage, Handling and Transfer The Commodities Spacecraft shall support the standard Orbital Express Interface. Provisions for plumbing to and from the fluid transfer interface to on-board tankage shall be provided. Interface with the ASTRO on-board systems including communication, power and data shall be made available to the interface.

6.6 Hardware Payload Storage, Handling and Transfer The Commodities Spacecraft shall support the standard Orbital Express Interface. Provisions for storing electronic upgrade modules shall be provided. Interface with the ASTRO on-board systems including communication, power and data shall be made available to the interface.

6.7 Power and Power Distribution System The Commodities Spacecraft shall have sufficient power generating capacity and storage to perform the mission defined in the OEOS. This mission may have extended periods of time where there is little or no illumination of its solar panels due to pointing requirements of the ASTRO.

6.8 Propulsion System The propulsion system shall be designed to provide overall system performance consistent with the mission performance goals. In addition, the propulsion system shall be designed consistent with multiple missions, upgradability and multi-year life. Propulsion components may not need to be man-rated.

6.9 Tracking, Telemetry and Communications All communications systems should be robust and as reliable as possible. The Offeror's communication architecture shall address all necessary changes to existing communication ground infrastructure. Data rates that allow adequate download of on-orbit telemetry for real-time monitoring of the mission is required. Receive capability to allow remote operation of the Commodities Spacecraft from the ground is may also be required.

6.10 System Environmental Survivability The Commodities Spacecraft Satellite shall be designed for the space environments existing in the regions of space the Commodities Spacecraft Satellite will occupy. These orbits and regions of space will be determined as a result of the economic trade studies done of satellite refueling and on-orbit electronics upgrade.

6.11 Integration and Test Integration and test of the Commodities Spacecraft shall follow best commercial practice.

6.12 Longevity / Durability The Commodities Spacecraft shall be designed for a mission lifetime determined by trade study as providing the highest economic return for satellite refueling and electronics upgrade operations.

6.13 Disposition / Disposal The Contractor shall provide their concept for Disposition/ Disposal of the Commodities Spacecraft at the end of its useful life.

7.0 Microsatellite Architecture

7.1 Spacecraft Bus The spacecraft structure is not limited to any existing or current spacecraft bus design. The goal is to develop Microsatellites that have stand-alone capabilities but may require addition basic “housekeeping” chores. Adequate interfaces must be provided to allow the microsatellites to draw upon power, thermal control, propulsion, etc that ASTRO can provide. The interface must also allow easy capture/docking of the Microsatellite and the ASTRO.

7.1.1 Design The bus design must be capable of meeting all of its primary mission requirements as well as the requirements to support the Standard Microsatellite to ASTRO interface.

7.2 Command, Data Handling and Processing System The on-board Vehicle Control System (VCS) must be compatible with the offeror’s CONOPS. It is desired that the VCS architecture is modular to the point that systems can be tested, replaced and/or changed without impact on the system outside of the module replaced. It is desired that the VCS coordinate the activities of all avionics sub-systems and provide appropriate interfaces to the Servicer Interface and Microsatellite when docked. The VCS shall allow both autonomous control of the vehicle systems and interaction with the mission management system as defined in the CONOPS.

7.2.1 Flight Control This function performs the actual mechanical operation of the spacecraft to accomplish the mission and should be highly automated. The functions continually monitor the present location and orientation and operate the thrusters and/or control systems to match the locations designated in the mission plan.

7.2.2 Navigation The navigation system shall provide accurate navigation throughout the mission and be capable of dynamically responding to course changes during all phases of the mission. The system shall be able to receive data from outside sources, such as Star trackers, optical sensors, GPS, etc and update the current S/C position based on that data.

7.2.3 System Status The VCS shall incorporated a system status architecture that allows autonomous on-board analysis, top-level mission control station monitoring and in-depth mission control station analysis.

7.3 Cooperative Servicing Aids System The Microsatellites shall have all required sensors to allow navigation during all on-orbit operations. This includes station keeping, orbit transfer, rendezvous, and final approach and docking with the ASTRO. As the majority of the final maneuvering for docking is performed by the ASTRO, the Sensors on the microsatellite may be a subset of those on the ASTRO.

7.4 Servicing Modes and States The Microsatellite architecture shall provide for all modes and states required to support the Microsatellite CONOPS. These modes and states include normal modes (for when the Microsatellite is performing its normal operations), orbital transfer mode(s) if required by the CONOPS, rendezvous and relative navigation modes if required by the CONOPS, docking modes, docked satellite modes, undocking modes, pause modes, and safe modes.

7.5 Microsatellite Interface. Interface with the ASTRO on-board systems including communication, power and data shall be made available to the interface.

7.6 Power and Power Distribution System The Microsatellites shall have sufficient power capacity to perform the mission defined in the OEOS. This mission may have extended periods of time where there is no illumination or connection to the ASTRO.

7.7 Propulsion/Attitude Control System The propulsion system shall be designed to provide overall system performance consistent with the mission performance goals. The attitude control system onboard the spacecraft must be able to maintain the spacecraft in a preplanned orientation for spacecraft health and communication with minimal use of reserves and intervention. In addition, the attitude control system must be capable of performing attitude control for inspection and docking upon approach by the ASTRO.

7.8 Tracking, Telemetry and Communications All communications systems should be robust and as reliable as possible. The Offeror's communication architecture shall address all necessary changes to existing communication ground infrastructure. Data rates that allow adequate download of on-orbit telemetry for real-time monitoring of the mission is required. Receive capability to allow remote operation from the ground is may also be required.

7.9 System Environmental Survivability The Microsatellites shall be designed for the space environments existing in the regions of space the Microsatellites will occupy. These orbits and regions of space will be determined as a result of the economic trade studies done.

7.10 Integration and Test Integration and test of the Microsatellites shall follow best commercial practice.

7.11 Longevity / Durability The Microsatellites shall be designed for a mission lifetime determined by trade study as providing the highest economic return.

7.12 Disposition / Disposal The Contractor shall provide their concept for Disposition/ Disposal of the Microsatellites at the end of their useful life.

8.0 Ground Control Facility

8.1 Facility The mission ground control facility should be capable of supporting the full range of OEOS objectives.

8.2 Coordination / Use Agreements Coordination and/or use agreements for all required facilities, both government owned and commercial, shall be defined for the OEOS and in place to support the OEDS.

8.3 Hardware / Software Modifications All modifications to hardware/software shall be fully documented and shall follow best commercial practices.

8.4 Mission Planning The overall mission objectives, ORUs to change out, quantity of fuel to transfer, rendezvous time, microsatellite hosting, etc is defined in the mission planning.

8.5 { TC \l1 "**}Executive-Level Mission Management** The actual steps the ASTRO and NEXTSat must perform to accomplish the mission is all defined in the Executive–Level Mission Planning.

8.6 { TC \l1 "**}Command, Data Handling and Processing System**

8.7 Tracking, Telemetry and Communications System All communications systems should be robust and as reliable as possible. Communications systems shall make use of existing ground infrastructure. Data rates that allow adequate download of on-orbit telemetry for real-time monitoring of the mission are required. Two-way communications, send and receive, capability to allow remote operation of the Commodities Spacecraft, the ASTRO, the NEXTSat and the microsatellite from the ground may also be required.

8.8 Manpower, Personnel & Training It is desired to minimize manpower and personnel requirements consistent with the offeror’s OEOS employment, maintenance and long-term support concepts. The training concept for maintenance and support personnel should be consistent with the requirements for limited manpower during non-operation time and full support during actual mission activities. A sufficient set of personnel shall be fully trained and certified at all times. The offeror shall propose a concept for bringing backup personnel up to operational proficiency levels.

8.9 Security The offeror shall provide adequate security to for all aspects of the OEOS.

9.0 Supportability

9.1 Reliability & Maintainability The OEOS shall reliable and easily maintained in all operational environments and fault tolerant to achieve availability and sufficient life to meet the requirements of the OEOS. On-board and ground based diagnostics shall be integrated. Particular attention should be placed on a highly reliable tracking, telemetry and communications systems to identify problems early.

9.2 Maintenance Planning It is desired to fully exploit commercial and innovative maintenance concepts such as prognostics, autonomous inspection, and system redundancy to minimize life cycle costs.

9.3 Launch and Mission Support Equipment

9.3.1 Ground Support Equipment (GSE) Support equipment, when required, should include all software and hardware to setup, support and maintain the system. Common test and support equipment should be used where feasible

9.3.2 Mission Support Equipment (MSE) The Support equipment should leverage existing equipment wherever its use will minimize costs. Ground stations and communications systems should use a basic design to allow the use of common equipment. Use of existing equipment is encouraged. Unique equipment, where required, should include all software and hardware to setup, support and maintain the system.

9.4 Manpower, Personnel & Training It is desired to minimize manpower and personnel requirements consistent with the offeror's OEOS employment, maintenance and long-term support concepts. The training concept for maintenance and support personnel should be consistent with the requirements for limited manpower during non-operation time and full support during actual mission activities. A sufficient set of personnel shall be fully trained and certified at all times. The offeror shall propose a concept for bringing backup personnel up to operational proficiency levels.

9.5 **Supply Support** Spares and repair parts shall meet all original equipment specifications. Critical or long lead parts shall be on hand for rapid replacement.

9.6 **Safety & Health Hazards** All Orbital Express components and operations including integration, test and launch shall comply with all applicable safety and health regulations

10.0 Systems Engineering/Program Management

11.0 System Test

12.0 Orbital Express Demonstration System (OEDS) The OEDS shall be designed to validate the critical technologies and satisfy the ATD objectives in a system with direct legacy to the OEOS. Ideally the OEDS design should incorporate the same system integration and shape, volume and mass as the OEOS. The OEDS design should be capable of fully addressing as many of the specific Orbital Express ATD technical objectives, defined in section 2.3, as possible, while providing best value to the Government. The contractor has the freedom to consider demonstration spacecraft scaling if it will enable their OEDS to achieve a significantly greater set of program objectives for a given cost. At a minimum, the OEDS will incorporate the OEOS satellite-to-satellite mechanical and electrical interfaces system enabling multiple satellite servicing cycles involving automated satellite-to-satellite transfers of both fluids and hardware, and an Auto-GN&C system enabling autonomous servicing operations within a relative reference sphere about a spacecraft functionally emulating both a NEXTSat/on-orbit Commodities Spacecraft. The mission ground control facility should be capable of supporting the exploration of the full range of Orbital Express ATD objectives. The plan will also consider the use of Government Furnished Equipment (GFE).

Concept definition, design trades and preliminary design will be completed for the Orbital Express Demonstrator System (OEDS) (i.e., prototype satellite-to-satellite mechanical and electrical interfaces, a prototype servicing spacecraft (to include the servicing spacecraft Auto-GN&C system), a spacecraft functionally emulating the prototype servicing architectures of both a NEXTSat and an on-orbit Commodities Spacecraft, and a supporting ground control facility). The OEDS design shall include continued risk reduction R&D activities; development, fabrication, integration and space-qualification of the OEDS; support spacecraft integration/launch; arrange ground control facility support for on-orbit test operations and conduct an on-orbit satellite servicing demonstration.

The OEDS on-orbit demonstration will be conducted in FY04, and will validate the technical feasibility of automated satellite servicing. It will demonstrate the key technologies for satellite-to-satellite servicing interfaces for both fluid and hardware transfers and an automated spacecraft GN&C system enabling satellite servicing operations. Residual on-orbit OEDS hardware will be transitioned to the Air Force to support follow-on risk reduction and operational evaluation activities described in the Orbital Express Transition Plan.

Section 845 "Other Transaction for Prototypes" Questionnaire

Offerors shall submit responses to each of the two questions, below, with their proposal. Please **DO NOT** provide "Boiler Plate" answers to these questions. Your response will form the foundation of a submission to DoD and Congress.

We prefer the response to each question consume no more than one page. However, if you need more space, please take it in the interest of providing complete responses. (A series of thought provoking questions is also provided to assist you in formulating your responses.) Responses are to be provided in offeror format.

1. **To what extent will the Orbital Express Section 845 "Other Transaction for Prototypes" agreement (if awarded to your team) contribute to a broadening of the technology and industrial base available for meeting Department of Defense needs?** *Your discussion must focus on how the use of this "Other Transaction" agreement will contributed to a broadening of the technology and industrial base available for meeting DoD needs.*

2. **To what extent will the Orbital Express Section 845 "Other Transaction for Prototypes" agreement (if awarded to your team) foster new relationships and practices that support the national security of the United States?** *The discussion must focus on how the use of an "Other Transaction" agreement has fostered new relationships and practices that support the national security of the United States.*

When formulating your responses to the two "Extent" questions, above, please consider the following:

The intention is for your answers to provide a brief explanation of the ways in which the use of a Section 845 "Other Transaction for Prototypes" agreement (if awarded to your team) ~~[under 10 U.S.C. 2371 CA/OT]~~, rather than a standard procurement contract/cooperative agreement, will assist the Department of Defense in better meeting U.S. national security policy goals and objectives. Specifically:

1. Will the use of the Section 845 "Other Transaction for Prototypes" agreement allow you to involve any commercial firms in the project that would not otherwise have participated? If so:
   a. Which firms are they?
   b. Are there provisions of the Orbital Express Section 845 "Other Transaction for Prototypes" agreement, or features of the award process, that will enable their participation? If so, specifically what they are?

c. What are the expected benefits of your team's participation (e.g., technology that is better, more readily available, or less expensive)? Please be specific about the benefits and explain why you expect to realize them.
d. Why would other firms not participate if a standard instrument was used? For example: Do the firms in question normally not do business with the Government? Do they do business with the Government only through "Other Transactions" or contracts for commercial items? Or, do they limit their volume of Federal contracts to avoid exceeding a threshold beyond which they would have to comply with cost accounting standards or some other Government requirement?

2. Will the use of the Orbital Express Section 845 "Other Transaction for Prototypes" agreement allow you to create new relationships among for-profit firms at the prime or subtier levels; allow you to create new relationships among business units of the same firm; or, or allow you to create new relationships between firms and nonprofit performers that will help DARPA get better technology in the future? If so:
   a. Between which participants were the new relationships formed?
   b. Why does your team believe that these new relationships will help DARPA get better technology in the future?
   c. Were there provisions of the Orbital Express Section 845 "Other Transaction for Prototypes" agreement, or features of the award process, that will enable your participation? If so, specify what they are.

3. Will the use of the Orbital Express Section 845 "Other Transaction for Prototypes" agreement allow traditional Government contractors to use new business practices in the execution of this prototype project that will help DARPA obtain better technology, get new technology more quickly, or get it less expensively? If so:
   a. Who are those contractors and what are the new business practices?
   b. What specific benefits do you believe DARPA will obtain from the use of these new practices, and why do you believe that to be so?
   c. Were there provisions of the Orbital Express Section 845 "Other Transaction for Prototypes" agreement, or features of the award process, that will enable the use of these new practices? If so, specify what they are.

4. Are there any other benefits of the use of the Orbital Express Section 845 "Other Transaction for Prototypes" agreement that you perceive will help the Department of Defense better meet its objectives in carrying out this prototype project? If so, what are they; how do they help meet defense objectives; what features of the Orbital Express Section 845 "Other Transaction for Prototypes" agreement, or award process, will enable DARPA to realize? Please be specific.

Glossary

ASTRO	Autonomous Space Transfer and Robotic Orbiter
ATD	Advanced Technology Demonstration
Auto-GN&C	Autonomous Guidance, Navigation & Control
C4I	Command, Control, Communications, Computers and Intelligence
CDR	Critical Design Review
CONOPS	Concept of Operations
DAB	Defense Acquisition Board
DARPA	Defense Advanced Research Projects Agency
DARPA/TTO	Defense Advanced Research Projects Agency/Tactical Technology Office
Delta V	Delta Velocity (change in velocity)
DFARS	Department of Defense FAR Supplement
DFAS	Department of Defense Finance and Accounting Service
DoD	Department of Defense
DS	Demonstration System (synonymous with Orbital Express Demonstration System, or OEDS)
EIA	Electronic Industries Alliance
EMD	Engineering and Manufacturing Development
FAR	Federal Acquisition Regulation
FDR	Final Design Review
FFRDC	Federally Funded Research and Development Center
FY	Fiscal Year
GEO	Geosynchronous Earth Orbit
GFE	Government Furnished Equipment
GFF	Government-Furnished Facility

GFI	Government-Furnished Information
GFP	Government-Furnished Property
GFS	Government-Furnished Supplies
GPS	Global Positioning System
GSE	Ground Support Equipment
GTO	Geo-Transfer Orbit
ICD	Interface Control Document
IDR	Initial Design Review
IMP	Integrated Master Plan
IMS	Integrated Master Schedule
IOR	Integrated Open Review
IPPD	Integrated Product and Process Development
IPR	In-Process Review
IR&D	Independent Research and Development
IS	Interim Standard
JTA	Joint Technical Architecture
LCC	Life-Cycle Cost
LRR	Launch Readiness Review
MAA	Months After Award
MMD	Mean Mission Duration
MS	Milestone
MSE	Mission Support Equipment
Msn	Mission
NDA	Nondisclosure Agreement
NEXTSat	Next generation satellite specifically designed to enable on-orbit, routine automated satellite servicing
NRO	National Reconnaissance Office
OCI	Organizational Conflict of Interest
OEDS	Orbital Express Demonstration System (synonymous with

	Demonstration System, or DS)
OEOS	Orbital Express Operational System (synonymous with Operational System, or OS)
OETP	Orbital Express Transition Plan
ORU	Orbital Replacement Unit
OS	Operational System (synonymous with Orbital Express Operational System, or OEOS)
OSC	Operational System Concept
PDR	Preliminary Design Review
QA	Quality Assurance
R&D	Research & Development
RAMP	Risk Assessment and Management Plan
S/C	Spacecraft
SCD	System Capability Document
SCI	Sensitive Compartmented Information
SETA	System Engineering and Technical Assistance
SRR	System Requirements Review
TAPIM	Technical Architecture Framework for Information Management
TDD	Task Description Document
TIM	Technical Interchange Mission
TPM	Technical Performance Measure
TT&C	Tracking, Telemetry & Communications
U.S.C.	United States Code
VCS	Vehicle Control System
VV&A	Verification, Validation & Accreditation